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Federal Express Tracking No.: 7923 5076 9873

October 16, 2003

Mr. Kevin Turner
USEPA REGION V
8588 Rt. 148
Marion, IL 62959

Clayton Project No. 15-03095.12

Subject: **Work Plan**
Conceptual Site Model
Hartford, Illinois

Dear Mr. Turner:

On behalf of the Hartford Work Group, Clayton Group Services, Inc. (Clayton) has prepared the enclosed work plan for the development of the Conceptual Site Model of Hartford, Illinois. The work plan also includes the installation, sampling, and analyses of five monitoring wells that may serve as sentinel wells regarding the Hartford Well Head Protection Area.

It is our understanding from the October 2, 2003 meeting in Collinsville, Illinois that the Agencies will provide comments on the work plan within two (2) weeks of your receipt of the plan. We would appreciate receiving any comments at your earliest convenience. If you have questions, please feel free to contact me directly at (630)-795-3207.

Sincerely,

Monte M. Nienkerk

Monte M. Nienkerk, P.G.
Senior Project Manager
Environmental Services

Enclosure: CSM Work Plan

cc: Hartford Work Group
Steve Faryan (USEPA)
Tom Binz (TT EMI / USEPA)
Jim Moore (IEPA, Springfield – 3 copies)
Chris Cahnovsky (IEPA, Collinsville – 2 copies)

15-03095.10ca001

Conceptual Site Model
Village of Hartford Work Plan

Hartford, Illinois

Clayton Project No. 15-03095.12.001
October 16, 2003

Prepared for:
THE HARTFORD WORK GROUP
Hartford, Illinois

Prepared by:
CLAYTON GROUP SERVICES, INC.
3140 Finley Road
Downers Grove, Illinois 60515
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CONTENTS

1.0 INTRODUCTION

This Work Plan describes the activities planned for the Conceptual Site Model (Model) of the Village of Hartford, Illinois (the "Village"). Figure 1-1 shows the general location of the Village. The Model will present the known information and data available at the time of the report.

1.1 CONCEPTUAL SITE MODEL WORK PLAN PURPOSE

The purpose of the Conceptual Site Model Work Plan is to:

- Present the known information regarding the physical setting, specifically, the geology and hydrogeology underlying Hartford.
- Prepare a Geographic Information System (GIS) database of the Village that will present the known information regarding the underground petroleum pipeline locations within Hartford and other pertinent information.
- Install new monitoring wells (five) to assess groundwater quality between the Hartford Well Head Protection Area (WHPA) and the known areas of impacted groundwater.
- Hydrogeologic testing, sampling, and groundwater analyses of the new monitoring wells.
- Collection of groundwater elevation data and free phase hydrocarbon (FPH) thickness data from the known current and proposed monitoring wells to delineate the FPH horizontal and apparent vertical extent in the Village.
- Identification of data gaps requiring additional investigative work in the Village.

2.0 PHYSICAL SETTING

The geology and hydrogeology of this area has been summarized in numerous reports previously submitted to the Illinois Environmental Protection Agency (Illinois EPA).

Available reports will be reviewed and used as the basis for the geologic and hydrogeologic conceptual model of the Village. If sufficient information is available an evaluation will be made concerning the stability of the FPH plume.

Any new information that can be provided by Work Group members will be incorporated into the development of this conceptual model as appropriate. The general nature of the requested information from Work Group members would include any investigation reports addressing the geology of the Village including boring/well logs, if available and information on groundwater cone of depression systems maintained by surrounding facilities. The existing information, additional information from the Work Group, and data from the planned new monitoring wells will also be used to create geologic cross sections of the area, groundwater contour maps, and apparent product thickness maps.

3.0 GEOGRAPHIC INFORMATION SYSTEM DATABASE

The purpose of a Geographic Information System (GIS) database is to provide a unified database for features of interest relative to the known FPH identified within the Village. The GIS database will provide a means to identify and accurately locate these features within the Village along with other additional apparent and potential sources of impacts of the FPH upon the Village. As such, the following types of information will be gathered to assist in understanding the source(s) of identified contamination and routes of exposure.

The location of Village features (e.g., petroleum product pipelines, roads, railroad tracks) are being entered in the GIS database along with geologic investigative features such as vapor control system borings and recovery wells. In addition, the locations of known releases of petroleum or hazardous substances within the Village are being entered into this database. The general nature of the information gathered from the Work Group members would include underground petroleum product pipelines, any additional known releases or other potential sources of petroleum or hazardous substance releases within the Village, and subsequent investigations (if any).

4.0 MONITORING WELL INSTALLATIONS

Five new monitoring wells will be installed to assess groundwater quality between the Hartford WHPA (McGuire et al., 2001) and the known areas of impacted groundwater related to the FPH plume beneath the Village. The WHPA is the surface area near the two active Hartford community water supply wells that may provide recharge to the aquifer over a five-year period. The new monitoring wells are intended to be located outside the known extent of FPH and dissolved phase petroleum-related analytes identified within the Village. Depending, in part, on the results of the groundwater sampling at the location of the new monitoring wells, these wells may be used as sentinel wells for future monitoring of the possible encroachment of the identified FPH and dissolved phase plume upon the Hartford WHPA. Figure 4-1 shows the general location of the proposed monitoring wells.

The wells have been placed at a distance that represents an approximate two year travel time to the WHPA boundary. A review of the WHPA report (McGuire et al., 2001) indicated a northerly radius of approximately 1,200 feet from the northernmost active well (Well IEPA # 60105) to the perimeter of the five-year WHPA measured in the direction of the historic groundwater flow which is discussed below. Dividing the distance (1,200 feet) by the time (5 years) yields a travel distance of approximately 240 feet per year. Thus, over a two-year period, travel distance is estimated at approximately 480 feet assuming groundwater flows in southerly or southwesterly direction toward the WHPA. However, for the past 70 years, the natural movement of groundwater has been altered in the Hartford vicinity due to large-scale water pumpage. The net effect of this drawdown is groundwater movement to the northeast (Clayton, 2003) as shown in

Engineering-Science Figure 22 presented in Appendix A. Based on this information, the active community water supply wells are upgradient of the known FPH extents.

A review of the Illinois EPA's LUST database has revealed the following information. As shown on Figure 4-1, two identified LUST sites exist on, or south, of Hawthorne Avenue. While one of the LUST sites (LUST B), located within the WHPA, has received a No Further Remediation (NFR) letter (dated 4/4/02 and recorded 4/26/02), the second LUST site (LUST A), approximately 150 feet northeast of the WHPA, is the location of two open LUST incidents. This open LUST site is potentially upgradient of the proposed monitoring wells based on historic groundwater flow direction within the Village.

Three other LUST sites, two open and one closed (NFR dated 2/14/97), have been identified within the Village of Hartford according to the Illinois EPA's LUST database, however, insufficient information is currently available to accurately locate these incidents within Hartford. All of the identified addresses are on South Delmar, which is indicative of locations south of Hawthorne Avenue, and, therefore, again potentially upgradient of the proposed monitoring wells.

4.1 SOIL BORINGS

Soil borings (used for the installation of monitoring wells) will be advanced using conventional drill rigs equipped with hollow stem augers. Although the collection of soil samples for laboratory analysis is not anticipated during monitoring well installation activities, soil samples may be collected dependent on field observations. Decontamination activities between borings are anticipated to be conducted at a designated location on the Premcor facility. Soil cuttings will be containerized and disposed off site.

All soil borings will be continuously sampled using a split-spoon or similar continuous split-barrel sampling device advanced before the auger. Soil samples will be described and classified according to the Unified Soil Classification System. Visual, photoionization detector (PID), and olfactory observations will be noted. Additional drilling and sampling details are provided in the attached Standard Operating Procedures (SOPs) 120 contained in Appendix B. This SOP may be modified based on field conditions.

4.2 MONITORING WELL INSTALLATION AND HYDROGEOLOGIC TESTING

Five new monitoring wells are proposed to be installed during conceptual site model field activities to serve as early notification of potential FPH or dissolved phase constituents encroachment upon the Hartford WHPA, obtain groundwater samples, collect hydrogeologic data, and determine the nature and extent of groundwater contaminants. Water generated will be containerized and managed at the Premcor facility's wastewater treatment plant.

All new wells are intended to be 2-inch inside-diameter (ID) polyvinyl chloride (PVC) wells constructed with 0.010-inch screen. Final screen length will be determined by field conditions. If unconfined (water table) conditions are encountered, the screen length may be up to 15 feet to account for fluctuation of the water table. Available information indicates that the water table may fluctuate up to 10 feet or more in some locations. If confined conditions are encountered, the screen length will be 5 feet. Boreholes for the monitoring wells will be drilled as specified in Section 4.1. Figure 4-2 presents a representative monitoring well installation diagram.

In-situ instantaneous hydraulic conductivity (slug) tests will be conducted at the wells that do not contain FPH to estimate the hydraulic conductivity of the formation materials in the vicinity of a well. This is intended to provide a range of hydraulic conductivity values for the saturated lithology screened by the monitoring wells.

Each monitoring well will be surveyed by an Illinois-licensed surveyor for vertical control referenced to mean sea level. In addition, the existing Village monitoring wells that can be found will also be surveyed for vertical control. Horizontal control will be tied to the State Plane Coordinate System by Clayton using a portable Global Positioning Satellite (GPS) instrument. This will provide a unified location database of existing wells within the Village.

Groundwater levels and apparent FPH thickness (if present) will be measured in both new and existing Village wells in order to determine horizontal hydraulic gradient and flow directions of groundwater, and delineate the apparent horizontal and vertical extent of the FPH.

Additional monitoring well installation, development and hydraulic conductivity testing details are provided in the attached SOPs 210, 212 and 230 contained in Appendix B. These SOPs may be modified based on field conditions.

4.3 MONITORING WELL GROUNDWATER SAMPLING

One round of groundwater samples will be collected (using the low flow sampling technique) from the five new monitoring wells (wells without FPH). The samples will be analyzed for the following petroleum indicator parameters: volatile organic compounds (VOCs) (including methyl tertiary butyl ether [MTBE]) using USEPA Method 8260B, polynuclear aromatics (PNAs) using USEPA Method 8310 and lead using USEPA Method 7000. Additional groundwater gauging, monitoring, sampling, and decontamination details are provided in the attached SOPs 220 and 415 contained in Appendix B. These SOPs may be modified based on field conditions.

5.0 CONCEPTUAL SITE MODEL SCHEDULE AND REPORTING

A draft of the conceptual site model can be presented to the United States Environmental Protection Agency (USEPA) and Illinois EPA within ten weeks of receiving USEPA approval of the work plan.

The report will present the known geological and hydrogeological conditions within the Village of Hartford. This will include current groundwater contour and apparent FPH extent maps along with geologic cross sections. The report will also include current known information regarding underground petroleum pipelines and other Village features of interest. In addition, the report will present the information gathered from the installation, sampling, and groundwater analyses of the five new monitoring wells. This information will be incorporated into the ongoing Hartford GIS database that Clayton is compiling.

6.0 DATA GAPS

Based on the information gathered as part of this Work Plan, data gaps indicating the need for further investigation or research may be identified. These data gaps may result in the need for additional field investigation in order to complete or enhance the conceptual site model of the Village. In this event, the nature of the further investigation or research will be discussed along with proposed steps to obtain this additional data. Upon completion of the additional investigative or research activities, the conceptual site model will be revised as necessary to incorporate this new data.

7.0 REFERENCES

Clayton Group Services, Inc., August 14, 2003. *Vapor Control System Evaluation, Village of Hartford, Hartford, Illinois.*

Engineering-Science, Inc., March 1992. *History of Hydrocarbon Releases in the Village of Hartford, Illinois.*

McGuire, M., J. Keller, K. Miller, and S. Esling, 2001. *Delineation of a Well Head Protection Area Hartford, Illinois.*

FIGURES

APPENDIX A

FIGURE 22 – 1992 ENGINEERING-SCIENCE REPORT FOR SHELL

APPENDIX B

STANDARD OPERATING PROCEDURES

APPENDIX B-1

STANDARD OPERATING PROCEDURE NO. 120 – BOREHOLE LOGGING AND MATERIAL CLASSIFICATION

APPENDIX B-2

STANDARD OPERATING PROCEDURE NO. 210 – WELL INSTALLATION

APPENDIX B-3

STANDARD OPERATION PROCEDURE NO. 212 – WELL DEVELOPMENT

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APPENDIX B-4

STANDARD OPERATING PROCEDURE NO. 220 – GROUNDWATER AND LNAPL LEVEL MEASUREMENTS

APPENDIX B-5

STANDARD OPERATING PROCEDURE NO. 230 – INSTANTANEOUS HEAD AQUIFER TESTS "SLUG TESTS"

APPENDIX B-6

STANDARD OPERATING PROCEDURE NO. 415 – LOW FLOW GROUNDWATER SAMPLING

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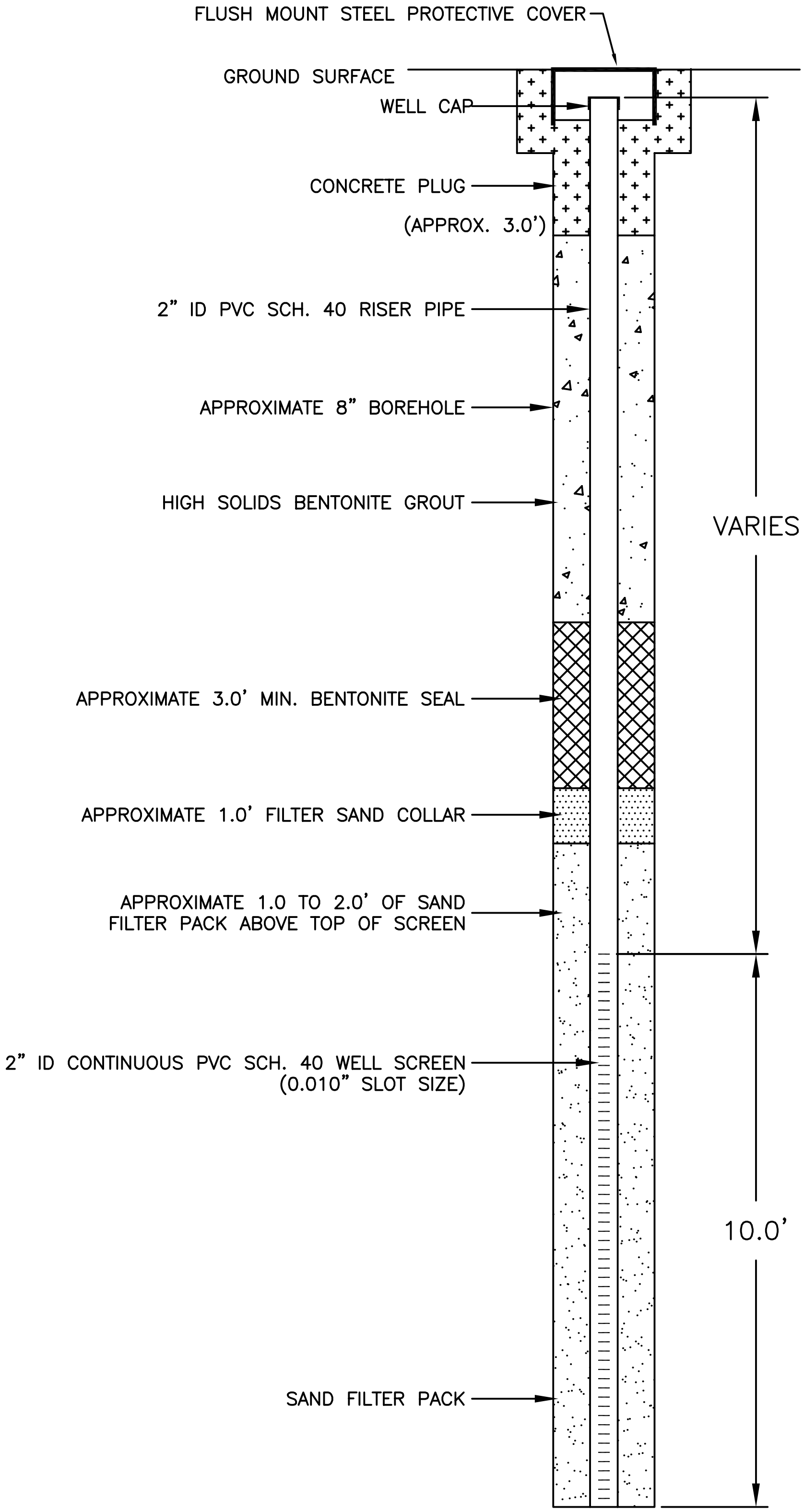
APPENDIX B-7

STANDARD OPERATING PROCEDURE NO. 500 – EQUIPMENT DECONTAMINATION



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DRAWN BY	BCP	
DATE	10-10-03	
SCALE	AS SHOWN	
CAD NO.	0309512001C	
PRJ NO.	15-03095.12	

REPRESENTATIVE
SENTINEL WELL INSTALLATION
DIAGRAM

THE HARTFORD WORK GROUP
HARTFORD, ILLINOIS

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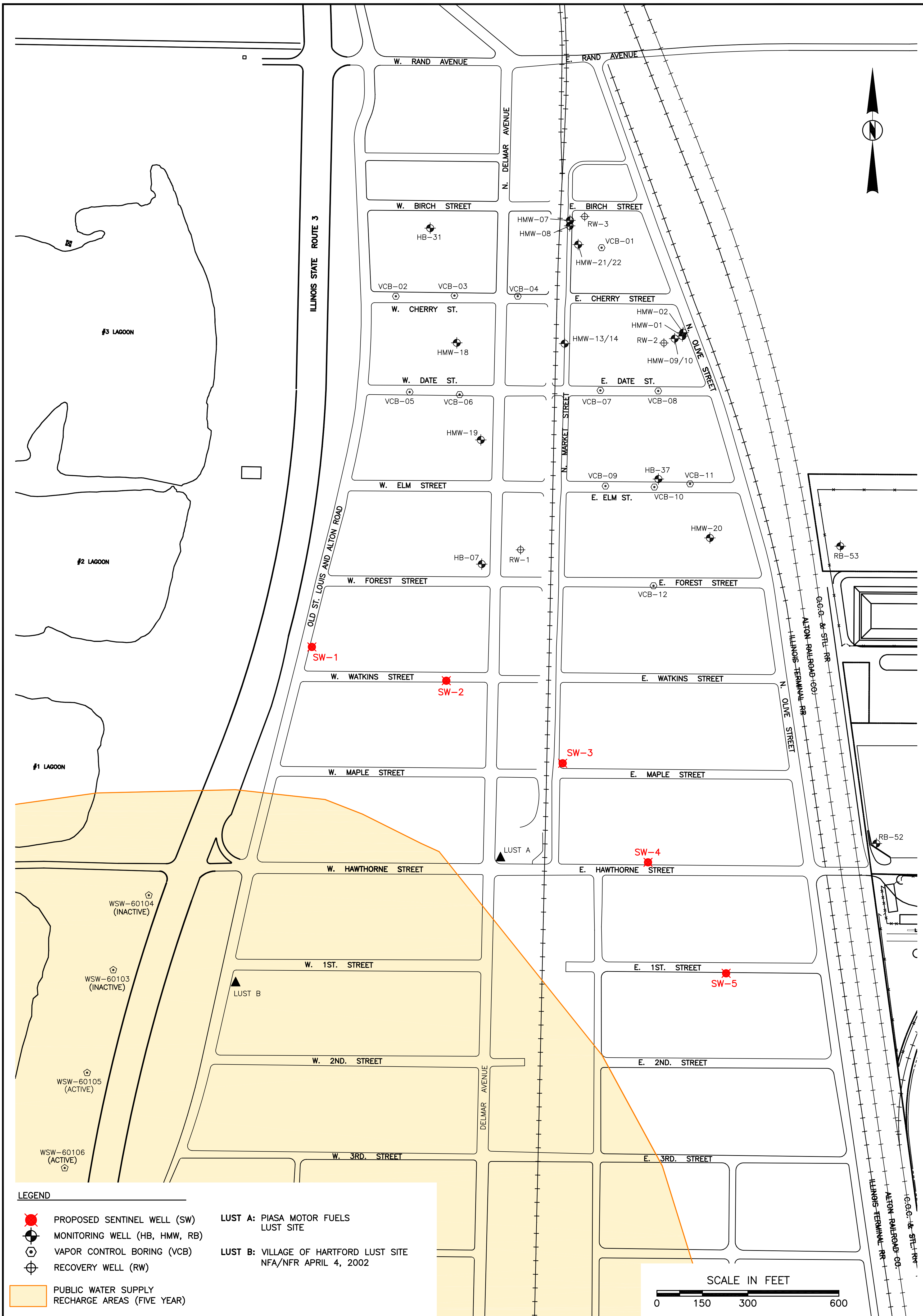
FIGURE
4-2



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DRAWN BY	BCP
DATE	10-10-03
SCALE	AS SHOWN
CAD NO.	0309512001A
PRJ NO.	15-03095.12

PROPOSED SENTINEL WELL LOCATIONS
VILLAGE OF HARTFORD

THE HARTFORD WORK GROUP
HARTFORD, ILLINOIS

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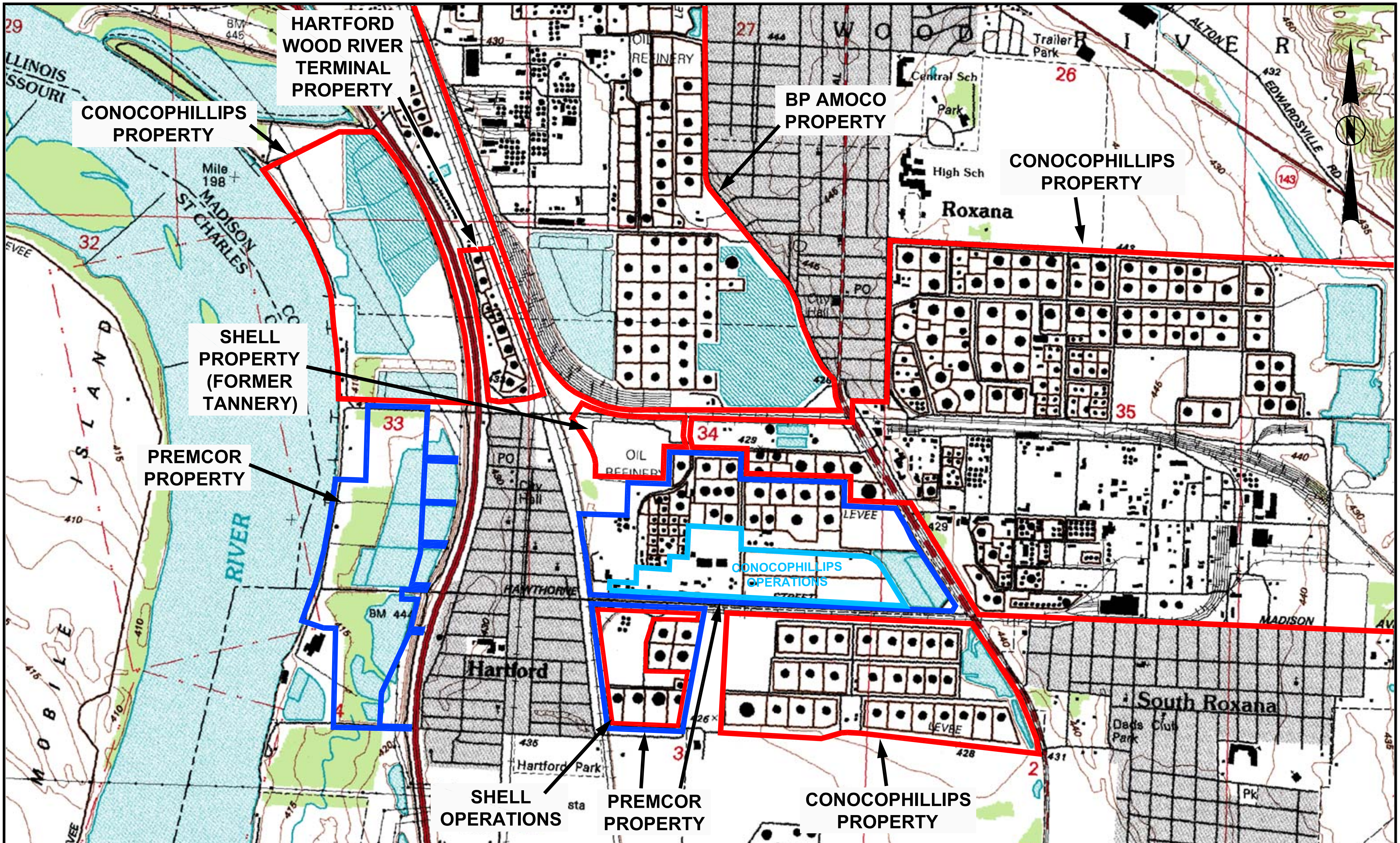
FIGURE 4-1



SCALE IN FEET

0 1000 2000 4000

SOURCE:
USGS 7.5 MINUTE SERIES TOPOGRAPHIC MAP
(WOOD RIVER, ILL.-MO. – rev.1994)

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DWN BY	BCP
DATE	10-10-03
SCALE	AS SHOWN
CAD NO.	0309512001B
PRJ NO.	15-03095.12

VILLAGE OF HARTFORD AND
SURROUNDING AREA MAP

THE HARTFORD WORK GROUP
HARTFORD, ILLINOIS

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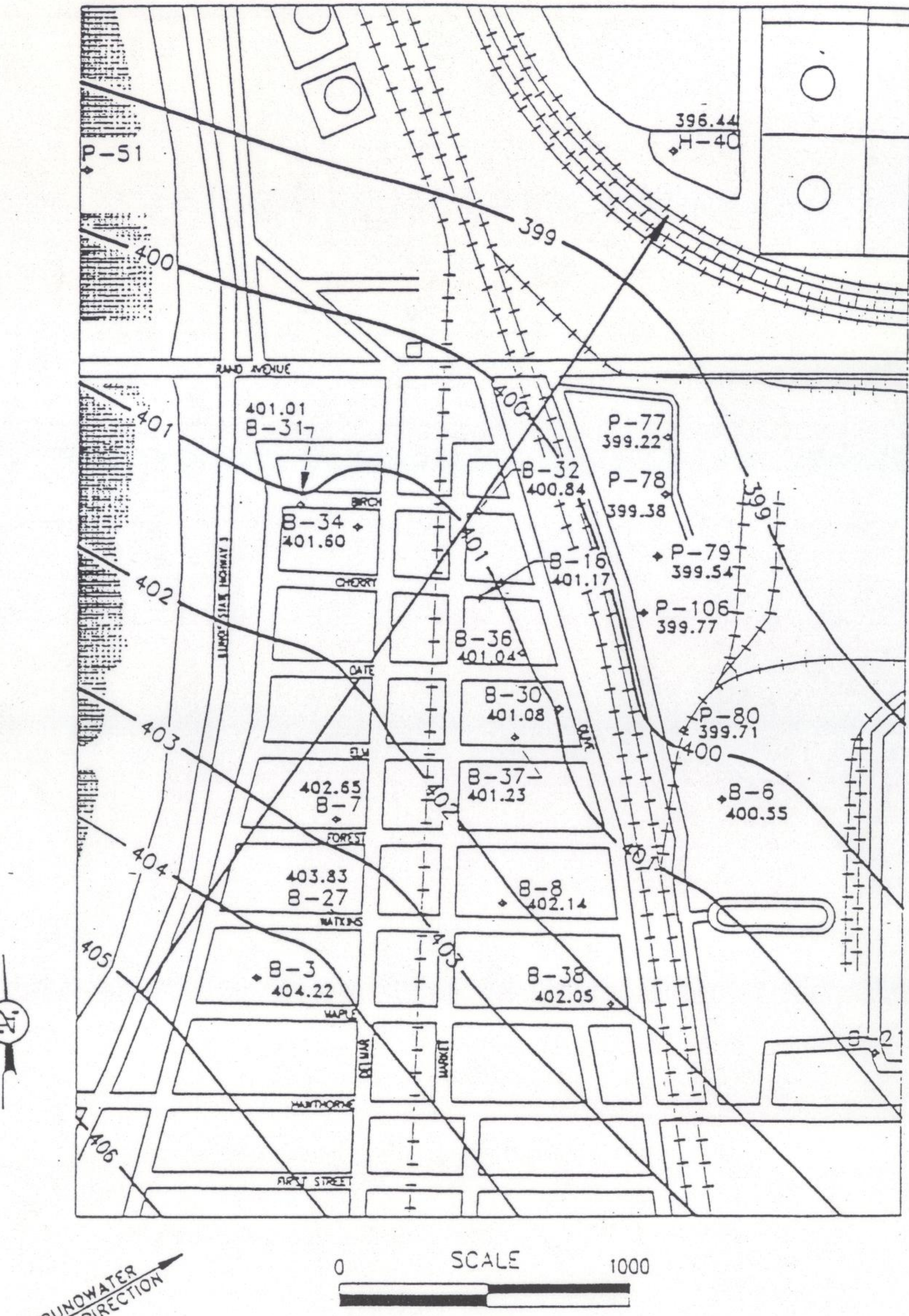
FIGURE
1-1

FIGURE 22

Corrected Groundwater Surface of the Main Aquifer-

Third Quarter 1990



Standard Operating Procedure No. 120

BOREHOLE LOGGING AND MATERIAL CLASSIFICATION

1.0 PURPOSE OF PROCEDURE

Standard Operating Procedure (SOP) No. 120 describes the guidelines for logging and classifying soil samples and rock cores during drilling and sampling operations as described in the Work Plan, or as otherwise specified, for the purpose of characterizing subsurface geologic conditions at the sampling site.

2.0 EXECUTION

2.1 GENERAL REQUIREMENTS

A. Geologic logging and/or material classification will be conducted for all subsurface and surface soil sampling and rock coring activities based on the following:

1. Visual observation of recovered samples.
2. Examination of drill cuttings.
3. Driller's observations of drilling rig behavior between sample intervals and during coring.
4. Identification of the location of groundwater.
5. Results of downhole tests (e.g., Standard Penetration Test).

B. Geologic logging and material classification shall be conducted only by a qualified geologist or a hydrogeologist or by a trained logging technician under the supervision of a geologist or a hydrogeologist.

C. Subsurface soil sampling and rock coring will be conducted in accordance with the guidelines specified in SOP No. 200.

D. Borehole materials may contain hazardous constituents, and the logging personnel should use caution when extruding and examining samples to prevent exposure. Air monitoring, use of personal protective equipment, and other safety practices while logging will be in accordance with the approved Site Health and Safety Plan (SHSP).

E. Tools and equipment used while logging boreholes shall be decontaminated between boring locations and prior to each sampling event in accordance with the requirements of the QAPP and SOP No. 500.

F. Field data and observations associated with borehole logging shall be documented during logging and for all drilling and sampling activities in accordance with SOP No. 110, if not otherwise specified herein. All field drilling activities should be recorded in a field logbook; boring log forms (Attachment 1) should be used to allow for added detail and organization of field data.

2.2 LOGGING EQUIPMENT AND SUPPLIES

The geologist/hydrogeologist should maintain a collection of logging equipment and supplies needed for sample handling and logging. The equipment and supplies generally used, but not limited to, are listed below.

- Soil Sampling and Logging Equipment and Supplies:
  - Stainless-steel butcher knife
  - Aluminum foil
  - Paper towels
  - Slim stainless-steel spatulas or icing spreaders
  - Ruler, tape measure (in 0.01-inch increments)
  - Color chart
  - Appropriate sample containers and lids
  - Logbook and field document forms (as required)
- Rock Coring and Logging Equipment and Supplies:
  - Tape measure (in 0.01-inch increments)
  - Comparative charts for grain size, sphericity, and percentages of silt, clay, and sand
  - Hand lens
  - Pens (indelible ink)
  - Core box(es)

- Other Supplies:
  - Camera
  - 5-gallon plastic buckets and wire brushes
  - Decontamination fluids and supplies
  - Vinyl surgical gloves
  - Plastic bags
  - Distilled water
  - Personal protective equipment, if necessary

2.3 LOGGING AND DOCUMENTATION

A. The geologist/hydrogeologist shall record all pertinent drilling information on the boring log forms (Attachment 1). The following technical information shall be recorded, as a minimum:

1. Project name and number.
2. Location (well or boring number) or other sample station identification, including a rough sketch.
3. Name of geologist or hydrogeologist overseeing the drilling operation.
4. Approximate ground elevation based on topographic map information.
5. Well installation or boring date.
6. Drilling contractor, type of rig, personnel, and equipment.
7. Drilling method and fluid used.
8. Drilling fluid gain or loss.
9. Depth of fluid losses.
10. Problems with drilling rig.
11. Water levels encountered during drilling.
12. Presence and depth of petroleum product.
13. Casing type and diameter.
14. Screen type and diameter.
15. Rock and/or soil classification and lithology.
16. Lithologic changes and boundaries.

B. Additionally, when rock coring is performed, the following information shall be recorded:

1. Top and bottom of cored interval.
2. Core length.
3. Coring rate in minutes per foot.
4. Percentage of sample recovered.
5. Core breakage due to discontinuities (natural fractures vs. coring-induced breaks).
6. Total core breakage.
7. Number of breaks per foot.

C. The geologic boring log forms should also include a complete visual lithological description of the soil/rock, description of any tests conducted in the borehole, and/or placement and construction details of wells.

2.4 SOIL SAMPLE CLASSIFICATION AND DESCRIPTIONS

2.4.1 Description of Hierarchy

The required order of terms is as follows:

1. Primary soil type followed by gradation modifier, if appropriate.
2. Secondary and tertiary (if needed) soil type modified by "slightly" or "very," if appropriate.
3. Color, if appropriate.
4. Texture.
5. Consistency, relative density, or the degree of cementation.
6. Structure.
7. Moisture content.
8. Trace components, sorting, and condition of sample.
9. Contamination, if encountered.

2.4.2 Soil Types

Soil description and classification shall be in accordance with the Unified Soils Classification System (ASTM D2488-84). The order and presentation of the terms is as follows:

1. Major soil component of that portion of the soil which is the predominant grain size constituent. Nouns are used and are unabbreviated and capitalized (i.e., CLAY, SILT, SAND, or GRAVEL); "TOPSOIL" is an adequate single term for the naturally occurring organic soil found at the ground surface.

2. Secondary and tertiary (if needed) component greater than 20 percent of total, if present adjective used (i.e., clayey, silty, sandy, or gravelly).

2.4.3 Color

The color descriptions should be consistent with the Geological Society of America (GSA) Rock Color Chart. Numerical Munsell notation is acceptable, but a written description is preferred. The major color is listed first with any accessory colors thereafter (e.g., clay, yellow brown with occasional light-green mottles). If secondary or tertiary descriptors are used, the color designation follows each descriptor.

2.4.4 Consistency and Relative Density

The relative density of cohesionless soils and the consistency of cohesive soils should be included in visual classifications. Attachment 2 can be used in describing the consistency of cohesive soils, and Attachment 3 can be used in describing the relative density of cohesionless soils.

2.4.5 Miscellaneous Descriptions

A. *Structure* – Some soils possess structural features (e.g., fissures, slickensides, or lenses) and, if so, are described.

B. *Moisture Content* – Criteria for describing the moisture content of cohesive soils are described in Attachment 4.

C. *Accessories or Inclusions* – Elements such as rock fragments, fine roots, or nodules are included in the soil description following all other modifiers for the major components of the soil matrix. Any mineralogical or other significant components are described here.

D. *Contamination* – If monitoring or visual observations indicate the presence of contamination, it should be noted in detail.

E. *Descriptors* – To provide consistency in logging soils, a summary of descriptor guidelines is provided in Attachment 5.

F. *Measurement* – All lengths and measurements are recorded in feet and tenths of feet.

2.5 ROCK CLASSIFICATION

2.5.1 Lithology and Texture

A. The geologist/hydrogeologist should describe the lithology of the rock and its mineral composition. The geological name, such as granite, basalt, or sandstone, usually describes the rock's origin.

B. The stratigraphic unit should be identified and assigned the local geological name, if appropriate. Stratigraphic age or period should be identified, if possible.

C. Modifiers should be included to describe rock texture, including grain size, sorting, packing, cementation, etc. (i.e., interlocking, cemented, or laminated-foliated).

2.5.2 Color

The color descriptions should be consistent with the GSA Rock Color Chart. Numerical Munsell notation is acceptable. The major color is listed first with any accessory colors thereafter (e.g., shale, bluish-gray with occasional light-green laminae). If secondary or tertiary descriptors are used, the color designation follows each descriptor.

2.5.3 Hardness

Terms used to describe hardness are described below. One common method to determine hardness is the Mohs Scale of Hardness defined as follows:

Descriptive Term	**Defining Characteristics**
Very Hard	Cannot be scratched with knife. Does not leave a groove on the rock surface when scratched.
Hard	Difficult to scratch with knife. Leaves a faint groove with sharp edges.
Medium	Can be scratched with knife. Leaves a well-defined groove with sharp edges.
Soft	Easily scratches with knife. Leaves a deep groove with broken edges.
Very Soft	Can be scratched with fingernail.

2.5.4 Weathering

Terms used to describe weathering are described below:

Descriptive Term	Defining Characteristics
Fresh	Rock is unstained. May be fractured, but discontinuities are not stained.
Slightly	Rock is unstained. Discontinuities show some staining on the surface, but discoloration does not penetrate rock mass.
Moderate	Discontinuous surfaces are stained. Discoloration may extend into rock mass along discontinuous surfaces.
High	Individual rock fragments are thoroughly stained and can be crushed with pressure of a hammer. Discontinuous surfaces are thoroughly stained and may crumble.
Severe	Rock appears to consist of gravel-sized fragments in a "soil" matrix. Individual fragments are thoroughly discolored and can be broken with fingers.

2.5.5 Rock Matrix Descriptions

A. Grain size is a term that describes the fabric of the rock matrix. It is usually described as fine-grained, medium-grained, or coarse-grained. The modified Wentworth scale should be used.

B. A description of bedding (after Ingram, 1954) or fracture joint spacing should be provided according to the following:

Spacing	Bedding	Joints/Fractures
<1 inch	Very thin	Very close
1 inch - 4 inches	Thin	Close
4 inches - 1 foot	Medium	Moderately close
1 foot - 4.5 feet	Thick	Wide
>4.5 feet	Very thick	Very wide

C. Discontinuity descriptions are terms that describe number, depth, and type of natural discontinuities. They also describe density, orientation, staining, planarity, alteration, joint or fracture fillings, and structural features.

2.6 ROCK CORE HANDLING

A. Core samples must be placed into core boxes in the sequence of recovery, with the top of the core placed in the upper left corner of the box. At the bottom of each core run, spacer blocks must be placed to separate the runs. The spacer should be indelibly labeled with the drilling depth to the bottom of the core run; regardless of how much core was actually recovered from the run. Figure 120-1 shows the proper storage and labeling methods.

B. Spacer blocks should be placed in the core box and labeled appropriately to indicate zones of core loss, if known. Where core samples are removed for laboratory testing, blocks equal in length to the core removed are placed in the box. If wooden core boxes are used, spacer blocks should be nailed securely in place.

C. The core boxes for each boring should be consecutively numbered from the top of the boring to the bottom. Core from only one boring should be placed in a core box.

D. The core boxes containing recovered rock cores should be photographed.

E. One core box should be photographed at a time. The box lid is framed in the picture to include information printed on the inside of the lid. Be sure to include a legible scale in the picture. Photographs are taken in the field most easily and efficiently with natural light and while the core is fresh.

F. When transporting a boxed core, the box should be moved only if the lid is closed and secured with tape or nails.

BORING LOG FORM

Boring / Well No.:	Start Date & Time:	Boring Location / Coordinates:
Logged By:	Finish Date & Time :	
Project Name:	Project No.:	N
Project Location:		
Drilling Co.:	Drilling Equipment:	
Driller:	Drilling Method:	
Ground Elevation:	Top of Casing Elevation:	
Borehole Dia.:	Development Method:	
Outer Casing Dia / Material / Length:		
Inner Casing Dia. / Material / Length:		
Screen Interval / Material / Slot size:		
First Water:	Static Water:	
Date:	Date:	
Time (hrs):	Time:	Surface Conditions:

DEPTHS		DESCRIPTION	GRAPHICS	SAMPLE INFORMATION							
Top	Bottom			I.D.	Interval	Recovery	Method	Moisture	Blow Count	PID or FID Measurements / Remarks	
										Scan	Headspace
0					to						
					to						
					to						
					to						
					to						
					to						
					to						

Boring / Well No.:	Start Date & Time:	Finish Date & Time :
Project Name:	Project No.:	Logged By:

DEPTHS		DESCRIPTION	GRAPHICS	SAMPLE INFORMATION							
										PID or FID Measurements / Remarks	
Top	Bottom			I.D.	Interval	Recovery	Method	Moisture	Blow Count	Scan	Headspace
					to						
					to						
					to						
					to						
					to						
					to						
					to						
					to						
					to						
					to						

FIELD CLASSIFICATION OF SOILS

CONSISTENCY OF COHESIVE SOILS

Consistency	Rule-of-Thumb	Blows * per Foot
Very Soft	Core (height = twice diameter) sags under own weight	0 - 1
Soft	Can be easily pinched in two between thumb and forefinger	2 - 4
Firm (medium stiff)	Can be imprinted easily with fingers	5 - 8
Stiff	Can be imprinted with considerable pressure from fingers	9 - 15
Very Stiff	Barely can be imprinted by pressure from fingers	16 - 30
Hard	Can not be imprinted by fingers	30

* Blows as measured with 2-inch OD, $1^{3}/8$-inch ID sampler driven 1 foot by 140-pound hammer falling 30 inches. See Standard Method for Penetration Test and Split-Barrel Sampling of Soils, ASTM D 1586-84. The resistances measured with a 2-inch ID, 2½-inch OD sampler driven with a 300-pound hammer falling 18 inches, as specified by some building codes, are roughly equivalent to those measured by the standard test. The consistency shown is not applicable if the blow counts are increased by the presence of rock fragments, chert, pebbles, etc.

RELATIVE DENSITY OF COHESIONLESS SOILS

RELATIVE DENSITY OF COHESIONLESS SOILS

Term	Rule-of-Thumb	Blows per Foot *
Very Loose	Easily penetrated with a ½-inch diameter steel rod pushed by hand	0 - 4
Loose	Easily penetrated with a ½-inch diameter steel rod pushed by hand	5 - 10
Medium Dense	Easily penetrated with a ½-inch diameter rod driven with a 5-pound hammer	11 - 30
Dense	Penetrated a foot with ½-inch diameter steel rod driven with a 5-pound hammer	31 - 50
Very Dense	Penetrated only a few inches with ½-inch steel rod driven with a 5-pound hammer	50

* Blows as measured with 2-inch OD, $1^3/8$-inch ID sampler driven 1 foot by 140-pound hammer falling 30 inches. See Standard Method for Penetration Test and Split-Barrel Sampling of Soils, ASTM D 1586-84. The resistances measured with a 2-inch ID, 2½-inch OD sampler driven with a 300-pound hammer falling 18 inches, as specified by some building codes, are roughly equivalent to those measured by the standard test. The consistency shown is not applicable if the blow counts are increased by the presence of rock fragments, chert, pebbles, etc.

CRITERIA FOR ESTIMATING MOISTURE CONTENT OF SOILS

CRITERIA FOR ESTIMATING MOISTURE CONTENT OF SOILS

Term	Relative Moisture	
	Cohesive Soil	**Cohesionless Soil**
Dry	Powdery	Not moist to the touch
Damp	Moisture content below plastic limit	Feels moist to touch, but cannot be molded
Moist	Moisture content above plastic limit, but below liquid limit	Feels moist to touch and can be molded
Wet	Moisture content above liquid limit	Free water drips from the sample

STANDARD SOIL DESCRIPTORS

STANDARD SOIL DESCRIPTORS

Grain Size Terminology		
Boulders		12-inch diameter or more
Cobbles		3- to 12-inch diameter
Gravel	Coarse	0.75 inch to 3 inches
	Fine	0.19 inch to 0.75 inch
Sand	Very Coarse	1 mm to 2 mm
	Coarse	0.5 mm to 1 mm
	Medium	0.25 mm to 0.5 mm
	Fine	0.06 mm to 0.25 mm
Silt		0.004 mm to 0.06 mm
Clay		0.004 mm or less

Consistency	
Very Soft	<2 blows/foot
Soft	2 to 4 blows/foot
Medium Stiff	5 to 8 blows/foot
Stiff	9 to 14 blows/foot
Very Stiff	15 to 30 blows/foot
Hard	>30 blows/foot

Density	
Very Loose	<2 blows/foot
Loose	2 to 10 blows/foot
Medium Dense	11 to 30 blows/foot
Dense	31 to 50 blows/foot
Very Dense	>50 blows/foot

STANDARD SOIL DESCRIPTORS

Estimated Plasticity, Silt/Clay Content		
Thread Diameter (inches)	PI	Identification
1/4	0	Silt
1/8	5 - 10	Clayey Silt
1/16	10 - 20	Clay and Silt
1/32	20 - 40	Silty Clay
1/64	40	Clay

Relative Proportions of Component	
Descriptive Term	Percent
Trace	1 - 10
Little	11 - 20
Some	21 - 35
And	36 - 50

Order and Punctuation	
1	Primary Soil Type
2	Secondary Soil Type
3	Tertiary Soil Type
4	Color
5	Consistency, Density (following each Soil Type)
6	Structure
7	Moisture Content
8	Trace Components, Sorting

Standard Operating Procedure No. 210

WELL INSTALLATION

1.0 PURPOSE OF PROCEDURE

Standard Operating Procedure (SOP) No. 210 describes the guidelines for the installation of monitoring wells, recovery wells, and observation wells as described in the Work Plan, or as otherwise specified. Monitoring wells and observation wells are installed to determine depth to groundwater and monitor fluctuations in groundwater elevation, to determine and monitor the depth and thickness of free phase petroleum products (if present), and obtain groundwater and/or free phase petroleum products samples for laboratory analysis. Recovery wells are installed to conduct groundwater pumping tests, free phase petroleum product recovery tests, and aquifer injection tests.

2.0 EXECUTION

2.1 DESIGN REQUIREMENTS

2.1.1 General Requirements

A. Well construction procedures should meet regulatory agency requirements. In addition, licensing and/or certification of the driller may be required.

B. A qualified geologist/hydrogeologist should be present during well installation to document the subsurface stratigraphy and construction details for each well.

C. The well designs should meet two basic criteria: (1) groundwater and/or other fluids (i.e., product) must move freely into the well, and (2) vertical migration of surface water or undesired groundwater to the well intake zone must, to the extent possible, be eliminated.

D. Factors that influence the location of wells should be considered and include the following:

1. Objectives of the Work Plan.
2. Location of facilities to be monitored.

3. Groundwater gradient.
4. Location of aboveground and underground utilities and manmade features.
5. Accessibility to desired areas.

2.1.2 Well Installation Materials Selection

A. Materials used in the construction of wells must remain essentially chemically inert with respect to free-phase petroleum products and dissolved contaminants in the groundwater for the duration of the remedial action.

B. The most commonly used well construction materials are PVC and stainless steel. PVC is the least expensive and easiest material to use. It is generally believed that PVC does not decompose in contact with groundwater containing low concentrations of organics.

C. Stainless steel is chemically inert, provides greater structural strength, and its use may be advantageous for large-diameter wells. Teflon casing is chemically inert but is very expensive.

D. Well casing and screen are available in threaded or unthreaded sections and typically in lengths of 5, 10, and 20 feet. Threaded pipe joints may be wrapped with Teflon tape to facilitate joining and to improve the seal. Sections of casing and screen should be assembled onsite to allow inspection immediately before installation. No solvents or adhesive compounds should be used on the threaded PVC or Teflon pipe.

E. Well materials should be cleaned before well installation. Two methods are acceptable: high-pressure hot water or steam, and detergent wash and distilled rinse. The former is preferred because it is easier and faster. Decontamination procedures are presented in SOP No. 500.

2.1.3 Well Types and Construction Specifications

Well types consist of monitoring and observation wells, recovery wells, and injection wells.

Monitoring and Observation Wells

1. The design of the wells consists of a section of slotted well casing or well screen connected to a riser pipe that extends above the ground

surface. Typically, a filter pack is placed in the annular space between the screen and the borehole wall. A 2-foot seal composed of hydrated bentonite pellets/chips is placed on top of the filter pack. The remaining height of annulus is sealed and/or grouted to the surface with a cement, bentonite/cement, or high solid bentonite grout. A lockable protective casing is constructed over the stick-up portion of the wells.

2. The diameter of the borehole and the inside diameter of any drill casing or hollow stem auger should be at least 3 inches greater than the outside diameter of the well casing and screen. This annular clearance facilitates the placement of the filter pack and grout around the outside of the well screen and casing.

3. The monitoring well screens are installed at the level of the water table, typically 15 feet long, to adequately monitor seasonal fluctuation of the water table.

2.2 BOREHOLE ADVANCEMENT

2.2.1 General

A. Boreholes used to install wells should be drilled with the following objectives:

   1. To provide geological data on subsurface conditions, namely stratigraphy, occurrence of groundwater, and depth to bedrock.

   2. To obtain representative disturbed or undisturbed samples for identification and laboratory testing.

   3. To install wells.

B. Prior to drilling, the following steps must be taken:

   1. Obtain permits from the appropriate state agency or agencies. There is a fee for permits, and drilling subcontractors usually include this as part of their fee.

   2. Notify (verbally or in writing) the appropriate state (and federal, if required) authorities in advance of the date that drilling is scheduled to begin.

3. Check for buried utility lines at all planned drilling locations. For reasons of safety and liability, no drill hole should be advanced if this step has not been completed.

4. Prepare and implement an approved Site Health and Safety Plan, adhering to all of its provisions for protection of the field crew.

5. Make provisions for disposal of all cuttings and discharge water in accordance with regulations. Permits may be required.

6. A qualified field geologist/hydrogeologist should be present onsite during drilling.

2.2.2 Selection of Drilling Method

A. Drilling methods should generally be limited to augering or rotary methods using water- or air-based drilling fluids.

B. Drilling methods should be selected based on the following general factors:

   1. The expected nature of the subsurface materials to be encountered in the boring.

   2. Site accessibility, considering the size, clearance, and mobility of the drilling equipment.

   3. Availability of drilling water and the acceptability of drilling fluids in the well.

   4. Diameter and depth of the well desired, including consideration of the need to set casing to prevent commingling of different transmissive zones.

   5. The nature and effects of contaminations expected during the drilling.

C. It should be recognized that many factors must be considered when deciding which drilling methods are most appropriate at a site under specific conditions. The factors related to hazardous waste investigation concerns for the drilling methods are summarized in Table 210-1. Advantages and disadvantages of each technique are identified therein.

2.3 MONITORING WELL INSTALLATION

2.3.1 Well Components

A. Typical well components in general order of placement are as follows:

1. Surface casing (if used)
2. Well casing
3. Screen(s)
4. Filter pack (gravel or sand pack)
5. Bentonite seal
6. Annular seal (grout)
7. Well head protector casing
8. Well head apron and guard posts

B. Surface casing, if needed, should be installed during borehole advancement for sealing the ground surface and subsurface transmissive zones not desired to be intercepted by the well from the borehole. Surface casing may also be needed to provide lateral support for loose unconsolidated formations that may slough into or collapse around the borehole during drilling or well installation. Casing may be extended in a telescopic fashion to permit casing through intermittent transmissive zones at greater depths to limit casing size and cost requirements.

C. Screens are perforated or slotted sections of casing typically of the same size and material as the well casing. The purpose of the well screen is to allow water and/or other fluids (i.e., product) to enter the well easily while preventing entry of large amounts of sediment. The slot size of the well screen is usually determined based on selection of the filter pack material. Both are commonly related to the grain size analysis of the formation material. Methods of determining appropriate screen slot size are listed in the EPA Manual of Water Well Construction Practices. Typically, 10-slot (0.010 inch slot width) or 20-slot (0.020 inch slot width) screens are used. The length of the screen depends on the sampling objective, water level fluctuations, product thickness, and thickness of the transmissive zone of the formation.

D. The well casing is the primary conduit to the desired borehole interval to be monitored. It serves to seal off other stratigraphic zones from the groundwater inside the well and provides unobstructed access to the well screens. The well casing extends from the top of the well screen to either above or flush with the ground surface. It is typically a single-walled pipe, flush-threaded, of the smallest diameter to facilitate sampling equipment and to support its own weight during installation.

E. A filter pack consisting of clean silica sand or pea gravel is placed in the annular space extending to at least 2 feet above the top of the screen. The filter pack will stabilize the aquifer formation, minimize the entry of fine-grained material into the screen, permit use of screens with different sizes of slot, and will increase the effective well diameter and water collection zone.

F. A bentonite seal consisting of pellets or chips should be installed above the filter pack to seal more effectively the well's water collection zone and to prevent the intrusion of overlying grout material into the filter pack. The bentonite pellets or chips should be slowly poured from the top of the borehole to prevent bridging. At least 3 feet of bentonite seal should be placed on top of the filter pack. If the bentonite seal is above the saturated zone, the bentonite pellets or chips should be hydrated with distilled water before grouting the remaining annular space. The hydrated pellets or chips should be allowed to set for a minimum of 15 minutes. Bentonite chips are preferred over pellets or balls when the seal is below the water table because the chips hydrate less rapidly and bridging is less common.

G. The annular space above the bentonite seal should be grouted with a cement, high-solids bentonite, or bentonite/cement grout up to 2 feet below the ground surface. The primary purpose of grouting is to minimize the vertical migration of water to the groundwater intake zone and to increase the integrity of the well casing. Grout design and installation is presented in SOP No. 211.

H. A 2-foot concrete plug should be installed above the annular grout. The concrete plug is used to set the protective well cover and to prevent frost heave of the concrete pad or apron. The concrete apron should be at least 3.5 inches thick, and it should be sloped to allow water drainage away from the well.

I. A protective cover with a locking cap should be installed after the well has been set. This cover will protect the exposed well casing from damage and will provide security against tampering with the well. The protective cover typically consists of a steel pipe or box around the well casing. The protective cover is set at least 2 feet into the concrete plug and wellhead apron. Weep holes (approximately ¼-inch diameter) are drilled into the base of the protective cover above the concrete apron to allow drainage.

J. Well-head aprons and guard posts, when used, provide additional surface protection to the well and are generally used for wells in high traffic areas or where a more permanent structure is desired.

2.3.2 Installation Procedures

A. Upon completion of the boring and subsurface sampling, it should be decided if a well will be installed. If the borehole diameter is not sufficient to install a well, either the borehole should be reamed using a larger diameter auger or a new borehole should be drilled. The new borehole should be at least 5 feet away from the initial boring. The initial soil boring will be grouted according to the procedures outlined in SOP No. 211.

B. If a well is not installed, the boring should be grouted in accordance with SOP No. 211.

C. Over-drilling should generally not be conducted to provide room for a well sump or additional filter pack material at the bottom of the borehole beneath the well casing. However, for wash rotary boreholes drilled in soft or highly plastic sediments, loose cuttings may fall to the borehole bottom after backwashing. In this case, it may be necessary to install a 2-foot layer of sand or gravel at the bottom of the boring to provide a firm base on which to set the well assembly to limit settling of the well casing and screen under its own weight.

D. For mud rotary boreholes, excess drilling fluids should be flushed from the borehole before installing the filter pack and grout seal. This can be accomplished by one or both of the following means:

1. Flush the well using the drilling equipment by pumping clean water down the drill pipe without circulating the returned fluid. This should be accomplished at low pump pressure and with care to avoid scouring or fracturing of the formations.

2. Insert casing and screens with a backwash valve on the bottom end, and then flush the borehole via the well casing at low pressures. The backwash valve not only provides an outlet for flushing, but also provides pressure relief so the screens are not damaged by the backwash fluid pressures.

The latter method should be conducted only if it is determined that the former is not possible, or if the drilling fluid must remain in place in order to install the filter pack.

E. Connect the screen and well casing while wearing latex gloves. Insert and lower the screen and well casing into the borehole in 10-foot increments. Hand-tighten connections to prevent them from leaking or becoming loose.

F. The final section of pipe should be measured and field cut, if necessary, before connecting to allow for a stick-up of 2½ feet. The cut end should be rasped and/or sanded smooth, taking care not to let fillings of casing material cling to the inside.

G. Backwash boring, if necessary, and pour in sand or gravel to seat and support the casing and screen. Based on boring and casing diameters, determine volume of filter pack material required to place the filter approximately 2 feet above the top of the screens. Install filter pack using the following methods, as appropriate.

1. Slowly pour filter material down annulus, being careful to evenly distribute the material around the casing and to avoid the material becoming packed between the sidewall and casing. Use a small-diameter pipe to dislodge packed material and to ensure adequate height and settlement of the filter pack.

2. Pour filter material down tremie pipe placed between boring sidewall and casing. In this method, clean potable or distilled water should be poured in along with the sand or gravel to prevent packing within the tremie. The bottom of the tremie should be kept above the filter material top by at least 5 feet to permit the filter material to evenly fall around the screens. Pack the material with the tremie pipe to ensure adequate height and settlement of the filter pack.

H. Pour bentonite pellets or chips down the annulus on top of the filter pack. The bentonite should be placed rapidly to prevent swelling and bridging around the casing when it hydrates. The bentonite should be allowed to hydrate for at least 15 minutes before grouting.

I. The remaining annulus should be sealed by pumping grout via a tremie pipe from the bottom of the annular space of the borehole until the grout returns to the surface displacing all remaining drilling fluid and formation water. The bottom of the tremie pipe should not be placed within 4 feet of the bentonite seal. Grouting mixture and technique should be in accordance with SOP No. 211. Grout will typically settle 1 to 2 feet. Remove excess grout to allow 2 feet of annular space for the concrete plug.

J. After the grout has stiffened sufficiently, install the concrete plug up to the ground surface. Set the protective cover, if possible, such that at least 2 feet of its length is embedded in the concrete below the ground surface. It should also be set such that it is not more than approximately 30 to 36 inches above the level where the sampling personnel must stand. A concrete pad approximately 3 feet in diameter and 3.5 feet thick should be formed around the base of the protective cover. The concrete pad should be sloped away from the protective cover to allow flow away from the well. Weep holes should be drilled through the protective cover nominally 1 inch above the top of the concrete apron.

K. The protective casing should be marked with identifying decals. A locking device should be installed to prevent unauthorized entry or vandalism of the well.

L. The top of the well casing should be notched with a file to provide a reference point in which to measure water and/or product levels. The elevation of the top of the well casing (reference point) and ground surface at the well should be surveyed relative to a USGS benchmark. The location of the well should also be surveyed in reference to the site coordinate system.

M. Develop well within 24 to 72 hours following well installation according to the well development procedures outlined in SOP No. 212.

3.0 DOCUMENTATION

A. Documentation of well installation should be the responsibility of the supervising geologist/hydrogeologist. A well completion report should be prepared after the well is installed. An example of a Well Completion Report is provided in Attachment 1.

B. The drilling and well installation activities should be recorded in the field logbook or on appropriate forms. The following minimum information should be recorded during and upon completion of every well installation.

1. Project name and number
2. Well location identification
3. Date of installation and time completed
4. Drilling methods, crew names, and rig identification
5. Drilling depths
6. Generalized subsurface stratigraphy
7. Total length of casing and screens
8. Depth to water and/or product
9. Depth to and length of screened intervals
10. Depth to top of filter pack
11. Depth to top of annular seal
12. Depth to top of bentonite seal
13. Depth to top of grout
14. Depth of surface casing (if necessary)
15. Elevation of top of well casing and ground surface
16. Name and signature of supervising geologist/hydrogeologist

C. The licensed driller should also prepare any state-required well completion forms in accordance with the state regulatory requirements. An example form is provided in Attachment 2.

TABLES

TABLE 210-1
Factors Affecting Choice of Drilling Methods

Method	Common Hole Diameter (inches)	Common Effective Operating Depth (feet)	Considerations Specific to Hazardous Waste Site Investigations
Continuous-Flight Auger	3 - 10	to 150	-- No drilling fluids commonly used that may affect groundwater quality.
			-- Potential for high concentrations of airborne contaminants near drilling personnel from borehole opening and cutting pile
			-- Relatively easy to clean and decontaminate equipment.
			-- User is in close proximity to the hazardous waste.
			-- Disposal of cuttings may be subject to regulation.
			-- Potential for borehole cave-in without casing, especially below water table.
Hollow-Stem Auger	5 - 12	to 100	-- No drilling fluids commonly used that may affect groundwater quality.
			-- Well installation possible inside HSA.
			-- Potential for high concentrations of airborne contaminants from borehole and cuttings.
			-- Below groundwater table, hydrostatic pressure must be maintained inside stem; water could affect groundwater quality.
			-- Difficult to clean and decontaminate inside surfaces of auger flights.
			-- Disposal of cuttings may be subject to regulation.
Water-Based Rotary	3 - 24	Very Deep	-- Water or drilling muds used may affect groundwater quality.
			-- Disposal of cuttings may be subject to regulation.
			-- Difficult to clean and decontaminate inside surfaces of drill stem.
Air-Based Rotary	3 - 24	Very Deep	-- Air flow may dilute contaminants and can be directed away from drilling personnel.
			-- May not require liquid drilling fluid, so groundwater quality would not be affected.
			-- Depending on soil characteristics and hole depth, water or foam may be required in small volumes; groundwater quality may be affected in these cases.
			-- Some air compressors use oil that may contaminate hole.
			-- Difficult to clean and decontaminate inside surfaces of drill stem and bit.

WELL COMPLETION REPORT

MONITORING WELL COMPLETION REPORT

Well No.:

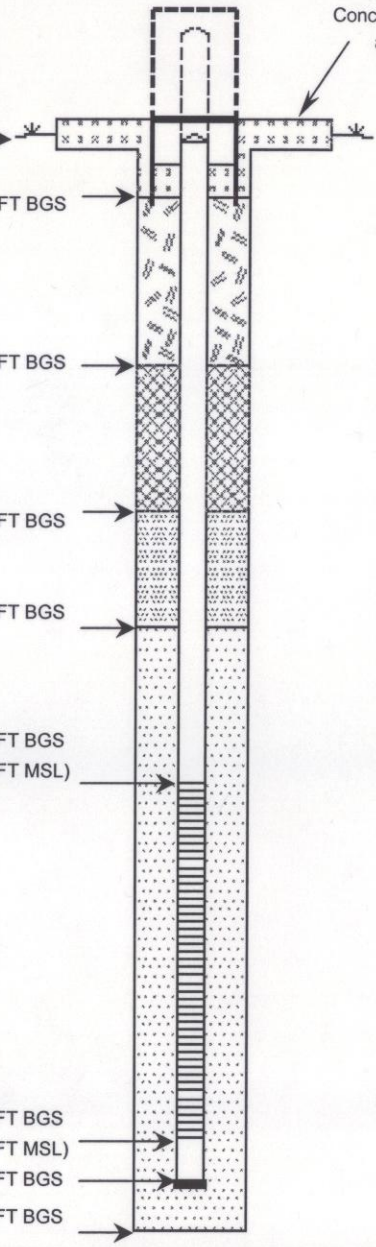
PROJECT INFORMATION	
Project Name:	Well No.:
Project Number:	Geologist:
Installation Date:	Drilling Co.:
Borehole O.D.:	Driller:
Total Screen & Riser Length (ft):	Rig Type:

Top of Casing ______ FT BGS/AGS
(______ MSL)

Concrete Pad and Plug

Surface ______ FT
(______ MSL)

Top of Grout ______ FT BGS



Top of Bentonite Seal ______ FT BGS

Top of Filter Collar Sand ______ FT BGS

Top of Filter Pack Sand ______ FT BGS

Top of Screen ______ FT BGS
(______ FT MSL)

Bottom of Screen ______ FT BGS
(______ FT MSL)

Base of Sump ______ FT BGS

Total Boring Depth ______ FT BGS

WELL CAP	
Type of Material:	
(Slip/Threaded/Locking):	
Locking (y/n):	

WELL RISER	
Type:	
Schedule:	
I.D.:	
Length:	
Thread Type:	
Centalizers (y/n):	

CONCRETE PAD AND PLUG	
Cement Type:	
Cement (Bags):	

GROUT MIXTURE/HIGH SOLIDS BENTONITE	
Cement Type:	
Cement (Bags):	
Bentonite Type:	
Bentonite (Bags):	
Water (Gal):	
Tremie Pipe (y/n):	

BENTONITE SEAL	
Type:	
Brand Name:	
Quantity:	
Hydrated (y/n):	
Tremie Pipe (y/n):	

FILTER COLLAR SAND	
Brand Name:	
Type:	
Size:	
Number of Bags:	
Tremie Pipe (y/n):	

FILTER PACK SAND	
Brand Name:	
Type:	
Size:	
Number of Bags:	
Tremie Pipe (y/n):	

WELL SCREEN	
Type:	
Schedule:	
I.D.:	
Length:	
Thread Type:	
Slot Size:	
Centralizers (y/n):	

END CAP	
Type of Material:	
(Slip/Threaded):	

NOTE

Standard Operating Procedure No. 212

WELL DEVELOPMENT

1.0 PURPOSE OF PROCEDURE

Standard Operating Procedure (SOP) No. 212 describes the guidelines for developing wells as described in the Work Plan or as otherwise specified. Well development is conducted to remove drilling fluids or mudcake from the filter pack, borehole wall, and formation materials to enhance the flow of groundwater and/or product into the well. Well development removes any loose formation materials (i.e., fine sand and silt) from the filter pack that may impact the integrity of groundwater and/or product samples.

2.0 EXECUTION

2.1 GENERAL REQUIREMENTS AND CONSIDERATIONS

A. Well development shall be conducted for all wells for the following reasons:

1. To restore the natural permeability of the formation adjacent to the borehole.

2. To remove clay, silty and other fines from the filter pack and well screen so that water and/or product samples will not be abnormally turbid or contain undue suspended matter.

3. To remove remnant drilling fluids and other contaminants from the well, filter pack, and formation material introduced during drilling.

B. All equipment, including pumps, hoses, containers, and bailers should be decontaminated before and after introduction into wells to be developed. Decontamination should be followed in accordance with SOP No. 500.

C. Personnel involved in well development procedures shall follow the prescribed Site Health and Safety Plan (SHSP).

2.2 DEVELOPMENT METHODS

2.2.1 Air Lifting

A. The airlift method involves pumping compressed air down an eductor pipe placed inside the well casing. Due to its inert characteristic, nitrogen is the preferred gas for air lifting. The use of standard air for well development may impact permeability of the formation surrounding the well screen and groundwater quality.

B. Pressure applied intermittently and for short periods causes the water to surge up and down inside the casing. Once the desired surging is accomplished, continuously applied air pressure should be used to blow water and suspended sediments upward and out of the well.

C. Considerable care must be exercised to avoid injecting air directly through the well screen. Air can become trapped in the formation materials outside the well screen and affect subsequent chemical analyses of water samples and hydraulic conductivity measurements. The bottom of the air pipe should not be placed below the top of the screened section of casing.

D. Another restriction of the use of air is the submergence factor. The submergence factor is defined as the height of the water column above the bottom of the air pipe (in feet) divided by the total length of the air pipe. To result in efficient airlift operation, the submergence factor should be at least 20 percent. This may be difficult to achieve in shallow monitoring wells or wells that contain small volumes of water.

2.2.2 Surge or Plunging

A. A surge block is a round plunger with pliable edges (constructed of a material such as rubber belting) that will not catch on the well screen. Moving the surge block forcefully up and down inside the well screen causes the water to surge in and out through the screen accomplishing the desired cleaning action. Close monitoring of the amount of pressure generated must be made to prevent cracking of the well casing or screen.

B. A well slug may also be used to create a surging effect through the filter pack and formation. A slug consists of a PVC rod or pipe (with capped ends) sufficiently weighted to rapidly sink in water. The slug is alternately lowered into and retrieved from the water in the casing to create a water level differential that induces flow into or out of the well to accomplish the desired cleaning action. This method is less aggressive than using a surge block.

C. For shallow wells or wells in which the water column in the casing is small, care must be exercised when lowering the slug so as not to drive the slug into the bottom of the casing or against the screens.

2.2.3 Bailing and Pumping

A. A bailer that is heavy enough to sink rapidly through the water can be raised and lowered through the water column to produce the surging action that is similar to that caused by a surge block or well slug. The bailer, however, has the added capability of removing turbid water and fines each time it is brought to the surface. Bailers are very useful for developing shallow and slow yielding wells. As with surge blocks, it is possible to produce pressure great enough to crack PVC casing. Bailers are the simplest and least costly method of developing a well, but are time-consuming.

B. Pumping can be used effectively in wells where recharge is rapid. The type and size of the pump used is contingent upon the well design. Pumps also allow removal of turbid water and fines. However, pumps are more difficult to decontaminate than a bailer is.

3.0 PROCEDURES

A. Measure the depth to groundwater in accordance with the guidelines in SOP No. 220 and calculate the standing water volume in the well to be developed. The standing well volume (V) is calculated using the following formula:

$$V = nA\,(B-C) + CD$$

where,

n = porosity of the filter pack

A = height (in feet) of the saturated filter pack

B = volume (in gallons per foot) of water in the borehole

C = volume (in gallons per foot) of water in the well casing

D = height of the standing water column (in feet) in the well

The height of the standing water column is calculated by subtracting the static water level from the total depth of the well. The volume of water in the well and borehole will vary with diameter.

B. The data collected during development should be recorded on the well development/groundwater sampling form as outlined in SOP No. 110. An example of this form is provided in Attachment 1.

C. Water quality parameters will be measured before and during well development. The water quality parameters should include pH, specific conductance, dissolved oxygen, temperature, and relative turbidity. Turbidity of the groundwater (including the presence of oil droplets, oil sheen, and hydrocarbon odors) should be noted if observed. The field measurements of the groundwater quality parameters should be performed in accordance with the guidelines in SOP No. 320.

D. Water quality parameters will be measured after each well volume is removed. The data will be recorded on the field activity form and/or field logbook.

E. The well will be developed for a minimum of 10 well volumes and until the water quality parameters stabilize. The criteria for parameter stability are summarized below:

1.	pH:	+ or	0.1 unit
2.	conductivity:	+ or	15%
3.	dissolved oxygen:	+ or	15%
4.	temperature:	+ or	0.5 C

F. Development water should be contained in 55-gallon drums and disposed onsite in accordance with the FOP.

G. Appropriate personal protection should be used when encountering product or strong product odors that exceed the action levels specified in the SHSP.

4.0 DOCUMENTATION

Well development activities should be documented in the field logbook, describing the procedures used and any significant occurrences that are observed during development such as apparent recharge rates in the well, condition of the groundwater, and organic vapor readings. Well development data including the depth to static water, standing water volume in the well, total volume of water removed, number of well volumes removed, and water quality parameters should be recorded on the field activity form (Attachment 1).

WELL DEVELOPMENT AND/OR GROUNDWATER SAMPLING FORM

GROUNDWATER DATA FORM

PROJECT INFORMATION					
EVENT		Well Development		Groundwater Sampling		Low-Flow Groundwater Sampling

Project Name	Well ID
Project No.	Start Date
Field Personnel	End Date

WELL AND DEVELOPMENT / PURGE INFORMATION			
Casing ID	Stick Up	Purging Method	Tube/Pump Intake Depth
Screened Interval		Pump Make, Size, or Type	Pump Rate

DEPTH MEASUREMENTS	INITIAL		FINAL	
	Depth	Time	Depth	Time
Product				
Groundwater from Top of Casing				
Casing Base from Top of Casing				

VOLUME PRODUCTION INFORMATION				
Volume Type:		Borehole		Well Casing
Linear Feet of Water in Well				
Amount Equal to One Volume				
Total Volumes Produced				
Well Purged Dry?				

NOTES:

PHYSICOCHEMICAL PARAMETERS

Date	Time (24 hour)	Flow Rate (____)	No. of Vol Removed (#)	Volume Purged (gal)	Depth to Water (ft BTOC)	Drawdown (ft)	Temp (^{o} C)	pH	Conduct. (mS/cm)	TDS (ppm)	Dissolv. Oxygen (ppm)	Eh (mV)	PID (ppm)	Turbid. (ntu)	Visual Clarity

GROUNDWATER DATA FORM

PROJECT INFORMATION

EVENT		Well Development		Groundwater Sampling		Low-Flow Groundwater Sampling
Project Name					Well ID	
Project No.					Start Date	
Field Personnel					End Date	

PHYSICOCHEMICAL PARAMETERS

Date	Time (24 hour)	Flow Rate (____)	No. of Vol. Removed (#)	Volume Purged (gal)	Depth to Water (ft BTOC)	Drawdown (ft)	Temp (^{o}C)	pH	Conduct. (mS/cm)	TDS (ppm)	Dissolv. Oxygen (ppm)	Eh (mV)	PID (ppm)	Turbid. (ntu)	Visual Clarity

Standard Operating Procedure No. 220

GROUNDWATER AND LNAPL LEVEL MEASUREMENTS

1.0 PURPOSE OF PROCEDURE

Standard Operating Procedure (SOP) No. 220 describes the guidelines for determining groundwater and LNAPL levels in monitoring wells, observation wells, and recovery wells as required in the Work Plan or as otherwise specified. The purpose of measuring groundwater and LNAPL levels will be to determine the depth of groundwater and/or LNAPL, hydraulic gradients, LNAPL thickness, and standing water volume in wells.

2.0 EXECUTION

2.1 GENERAL REQUIREMENTS

A. Water level and LNAPL (if present) measurements should be obtained at wells designated in the Work Plan. Water and LNAPL levels should be measured in referenced to a common elevation or datum, preferably to a USGS benchmark located at the site. Water and LNAPL depths should be measured from a reference point marked on the top of the casing, which is, in turn, referenced to a permanent benchmark.

B. Water and product level measurement devices shall be decontaminated as per SOP No. 500 or as specified in the Work Plan before and after measuring at each location.

C. Personnel obtaining water and product level measurements could be subject to exposure from contamination and should follow the Site Health and Safety Plan (SHSP) regarding this activity. Care shall be exercised to avoid direct skin contact while measuring water level and product depth. All equipment should be decontaminated before and after each measurement.

D. Water and product level measurements should be recorded in the field logbook and/or the field activity form. The water/product level measurements form is provided in Attachment 1.

3.0 DISCRETE WATER LEVEL MEASUREMENT METHODS AND PROCEDURES

3.1 METHODS

A. Discrete water level measurements should be made by determining the depth to the water surface from the top of the well casing at the fixed reference point. The fixed reference point is established by permanently marking a point on the northern outer edge (lip) of the well casing. Caution should be exercised so that filings do not fall into the well.

B. The depth to water can be determined using a steel add-on tape or electronic water level indicator. The steel add-on tape consists of a measuring tape that has 1-foot increments and a 1-foot section at the end of the tape with 0.01-foot increments. The end of the tape is coated with chalk and lowered into the well. The water depth is read from the saturated mark on the chalked tape and added to the depth interval measured at the top of the well casing.

Electronic water level indicators are conducting probes that activate an alarm and a light when they intersect the water. The sounder wire is marked in 0.01-foot intervals to indicate depth. All sounders are equipped with weights to maintain line tension for accurate readings.

C. Discrete water levels are typically required from a series of wells when data for preparing groundwater contour maps are needed. However, discrete water levels may also be required when monitoring the changes in water level during aquifer testing if aquifer response is sufficiently slow. Continuous water level measurements are discussed in Section 5.0.

3.2 PROCEDURES

3.2.1 Electronic Water Level Indicator

A. Lower the sounder wire until it just makes contact with the water in the well and the indicator light goes on or the alarm is sounded. Record the position of the wire relative to the reference point at the top of the well casing. Record the actual water level reading to the nearest 0.01-foot. Repeat to confirm depth.

B. Withdraw the sounder from the well.

C. Record the water depth in the field logbook and/or the field activity form.

D. Decontaminate the sounder wire and electrode in accordance with SOP No. 500.

4.0 DISCRETE LNAPL LEVEL MEASUREMENT METHODS AND PROCEDURES

4.1 METHODS

A. Discrete LNAPL or product level measurements should be made by determining the depth to the product and water surface from the top of the well casing at the fixed reference point. The fixed reference point is established by permanently marking a point on the northern outer edge (lip) of the well casing. Caution should be exercised so that filings do not fall into the well.

B. The depth of the product and water level should be obtained using an electronic oil/water interface probe. An oil/water interface probe has a multi-conducting probe that activates different signals, typically pulsating beeps and continuous alarms, when they intersect the product and water, respectively. The sounder wire is marked in 0.01-foot increments to indicate depth. The interface probe is equipped with a weight to maintain line tension and obtain accurate readings.

4.2 PROCEDURES

A. Check the interface probe battery by pressing the test button to ensure the device is operating properly before and after taking the level measurement. Daily battery checks should also be made and documented in the logbook.

B. Lower the interface probe until it makes contact with the product in the well and the product indicator light goes on or the pulsating alarm is sounded. Record the position of the wire relative to the reference point to the nearest 0.01-foot. Repeat to confirm the depth of the product.

C. Continue to lower the interface probe, through the product layer, until it makes contact with the water level in the well and the water indicator light goes on or the continuous alarm is sounded. Record the position of the wire to the reference point to the nearest 0.01-foot. Repeat to confirm the depth of the water.

D. Withdraw the probe from the well.

E. Record the product and water depth in the field logbook and/or the field activity form.

F. Decontaminate the sounder wire and probe in accordance with the guidelines in SOP No. 500.

5.0 CONTINUOUS WATER LEVEL MEASUREMENT METHODS AND PROCEDURES

5.1 PRESSURE TRANSDUCER METHOD

Continuous water level measurements are made by determining the height of the water column above a pressure transducer and electronically recording fluctuations in this height with a data logger. The continuous recording of height of water above the transducer is used for aquifer testing where rapid changes in water level are anticipated.

5.2 PROCEDURES

A. Enter the program into a data logger that has fully charged batteries. Alkaline batteries are preferred. During use, the battery voltage should not drop below the minimum voltage specified by the manufacturer; damage to the data logger and loss of recorded data could result.

B. Select a pressure transducer for use in a given well that is compatible with both water quality and anticipated pressure sensitivity range (i.e., 5 psi, 30 psi, etc.). The pressure range selected is dictated by the anticipated range in the water column above the transducer and by the desired precision in measurement.

C. Hook up the transducers to the data logger in the field following manufacturer's instructions. Typically, four to eight input channels are available on the system. Other factors affecting the sampling configuration include cable length; distance between monitored wells; terrain; local human activities (traffic, plant operations); and the ability to secure the system from weather and vandals.

D. Attach the transducer cable to the data logger and calibrate in air according to manufacturer's instructions. If multiple data loggers are used, internal clock synchronization should also be performed.

E. Measure water level and depth to the bottom of the well before lowering the transducer into the well. Water levels are measured with an electrical water level indicator; total depth of the well is measured with a device compatible with well depth.

F. Secure a sanitary fitting (commonly a gasket adapted to the cable diameter) at the surface of the well. Lower transducer into the well through the sanitary fitting to a depth between the water level and the bottom of the well. The transducer must be kept submerged during the period of measurement. Take care to keep the piezometric crystal at the tip of the transducer out of any fine sediment that has accumulated in the bottom of the well. On some transducers, the crystal is protected from sediment intrusion. Measure water level again; record the time indicated on the data logger digital display and water level. From these readings (and other periodic manual water level measurements), the water levels can be converted to elevations.

G. Transfer data stored in the data logger periodically to a portable computer. The frequency of data transfer depends on available memory and conditions encountered in the field. Data may be transferred as frequently as daily. If the data logger has a wrap-around memory, the information should be transferred so that records are not recorded over.

WATER LEVEL MONITORING FORM

WATER LEVEL MONITORING FORM

PROJECT INFORMATION	
Project Name	Date
Project No.	Field Personnel

WATER LEVEL MEASUREMENTS

Time (24 hour)	Well ID	TOC Elevation (ft MSL)	Depth to Water (ft BTOC)	Product Level (ft BTOC)	Water Elevation (ft MSL)	Product Elevation (ft MSL)	Product Thickness (ft)	PID (ppmv)	Comments

Standard Operating Procedure No. 230

INSTANTANEOUS HEAD AQUIFER TESTS "SLUG TESTS"

1.0 PURPOSE OF PROCEDURE

Standard Operating Procedure (SOP) No. 230 describes the guidelines for performing instantaneous head aquifer tests ("slug tests") as specified in the Work Plan or as otherwise specified. Instantaneous head aquifer tests are conducted to determine the hydraulic conductivity of formations materials in the vicinity of a well.

2.0 EXECUTION

2.1 GENERAL

A. Instantaneous head tests can also be described as falling head and rising head tests. These tests are used in situations where non-equilibrium methods and analyses are appropriate.

B. The application of a slug test involves inducing a sudden change in head (rising or falling) and measuring the response of the water level in the well.

C. Slug tests offer a quick and inexpensive method of obtaining hydraulic conductivity in the field. This method provides a good approximation of bulk horizontal permeability values for the localized zone surrounding a well with hydraulic conductivities less than or equal to 10^{-2} cm/sec.

D. The time required for a slug test to provide sufficient data is related to the volume of the slug, the hydraulic conductivity of the subsurface strata being tested, and the construction of the well. These factors must be such that several incremental changes in groundwater level can be practically measured during the test interval. Slug tests are performed for a minimum of 30 minutes.

E. If the top of the well screen extends above the water table, only a rising head slug test is performed.

F. If the permeability of the soil is such that the water level does not recover to at least 90 percent of the static head during a falling head slug test, a rising head test will not be performed due to dis-equilibrium effects.

2.2 METHODOLOGY

2.2.1 Well Evaluation

A. Select a well, based on well diameter and height of water column in the well, where an instantaneous head test can be performed in a reasonable length of time. It is desirable to run the test to 90 percent recovery (i.e., until 90 percent of the differential head created by insertion or removal of a mechanical slug is dissipated) (Hvorslev, 1951).

B. If the test is run in a piezometer, the filter length of the piezometer should be sufficiently long to provide a representative value of permeability within a 24-hour test period or longer.

2.2.2 Test Procedure

A. Falling Head Test

1. Measure the depth to the static water level in the well.

2. Insert a pressure transducer (5 or 10 psi) in the well at the proper depth interval specified by the manufacturer. Typically, the transducer is placed at a depth of 10 to 20 feet below the water level depending on the transducer pressure rating (2.3 feet per psi).

3. Connect the pressure transducer cable to the data logger and anchor it to a stationary object to prevent movement during the test. Use the following recording frequencies to set the data logger:

    - 0.2-second intervals from 0 to 2 seconds
    - 1-second intervals from 2 to 20 seconds
    - 5-second intervals from 20 to 120 seconds
    - 0.5-minute intervals from 2 to 10 minutes
    - 2-minute intervals from 10 to 100 minutes
    - 10-minute intervals from 100 to 1,000 minutes

- 100-minute intervals from 1,000 minutes to 1 week, if necessary
- Then at 1-minute intervals for 10 minutes

4. Quickly insert (DO NOT DROP) a mechanical slug into the well to displace the water level while simultaneously starting the data logger. The mechanical slug should consist of a 5-foot section of 1¼-inch diameter PVC pipe filled with clean sand and capped at both ends.

5. Anchor the slug cable or rope to a stationary object (e.g., bumper post) to prevent movement.

6. Record data until 90 percent of the displaced head has recovered. The time required for 90 percent recovery is a function of soil/rock permeability and borehole geometry and may vary from a few minutes to several days. Generally, a minimum of 30 minutes should be allowed for each test.

7. Stop the data logger, download data, and record data on the field activity sheet (see Attachment 1) and/or field logbook.

B. Rising Head Test

1. Measure the depth to the water level (the depth at approximately 90 percent recovery to static water level).

2. Reset data logger to record new data set.

3. Quickly pull the mechanical slug out of the well while simultaneously starting the data logger.

4. Using the same monitoring frequency listed above; record the data until 90 percent of the displaced head has recovered. Generally, a minimum of 30 minutes should be allowed for each test.

5. Stop the data logger, download the data, and record the data on the field activity sheet and/or field logbook.

2.3 SELECTED ANALYTICAL PROCEDURES FOR DATA REDUCTION

Numerous authors have developed methods for analyzing data from instantaneous head tests. The slug test data will be analyzed and the hydraulic conductivity will be calculated using a computer software package called AQTESOLV. AQTESOLV is an interactive program that uses statistical parameter estimation methods and graphical curve-matching techniques to analyze aquifer test data. The methods of Bouwer and Rice (1976) and Cooper et al. (1967) will be used to determine hydraulic conductivity from slug test data obtained from unconfined and confined aquifers, respectively. These methods are discussed below.

2.3.1 Unconfined Aquifer

Bouwer and Rice (1976) have developed a procedure that considers the effects from fully or partially penetrating wells, the radius of the gravel pack, and the effective radius of influence of the test in unconfined aquifers. The procedures for this method are provided in the reference document. This method is summarized in Attachment 2.

2.3.2 Confined Aquifer

Cooper, Bredehoeft, and Papadopulos (1967) developed a set of type curves for estimation of the transmissivity (T) of a confined aquifer after injection or withdrawal of a known volume of water or mechanical slug. The hydraulic conductivity is calculated by the relation $K = T/b$ where b is the thickness of the confined aquifer and K is the hydraulic conductivity of the formation materials. The procedures for this method are provided in the reference document. This method is summarized in Attachment 3.

FIELD PERMEABILITY TEST DATA SUMMARY FORM

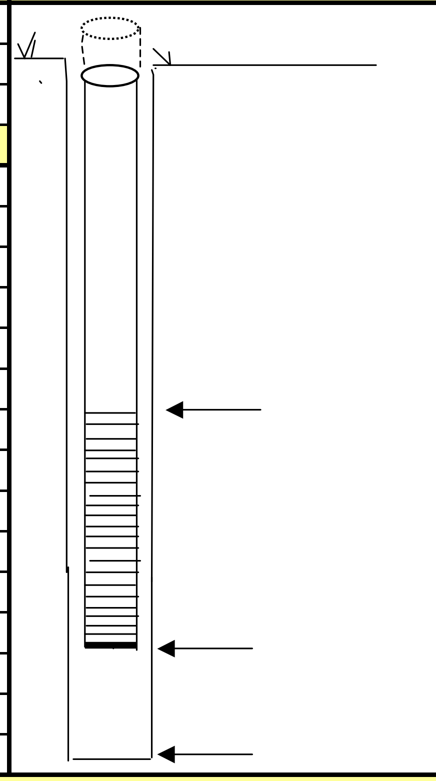
SLUG TEST DATA FORM

PROJECT INFORMATION		
Project Name	Well ID	
Project No.	Test Date	
Field Personnel	Confined	Unconfined

EQUIPMENT INFORMATION
Data Logger Type / Model No.
Transducer Type / Model No.
Slug Length / Volume

GENERAL INFORMATION				
Static Groundwater Elevation	ft MSL			
Ground Surface Elevation	ft MSL			
Top of Casing Elevation	ft MSL			
Well Stick-up		ft	0.0	cm
Depth to Water		ft	0.0	cm
Diameter of Well Casing		in	0.0	cm
Diameter of Borehole at Screen		in	0.0	cm
Screen Interval	-	ft BG	0 - 0	cm BG
Screen Length		ft	0.0	cm
Base of Boring		ft BG	0.0	cm BG
Base of Upper Confining Unit		ft BG	0.0	cm BG
Top of Lower Confining Unit		ft BG	0.0	cm BG
Saturated Thickness (b)		ft	0.0	cm
Static Height of Water in Well		ft	0.0	cm
Geology of Aquifer				

ILLUSTRATION OF INFORMATION



SLUG TEST MEASUREMENT INFORMATION

Parameter	Falling Head				Rising Head			
Initial Water Level Above Transducer		ft	0	cm		ft	0	cm
Initial Drawdown/Recovery		ft	0	cm		ft	0	cm

SLUG TEST RESULTS

Falling H	Rising H	Analysis Method	Parameter	Calculated Value and Units

Notes:

SLUG TEST METHOD FOR UNCONFINED AQUIFERS

REFERENCE:

H. Bouwer and R. C. Rice, 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, Vol. 12, No. 3, pp. 423-428.

SOLUTION: $$\ln s_o \quad \ln s_t = \frac{2\,K\,L\,t}{r_c^2 \ln(r_e/r_w)}$$

where:

s_o = initial drawdown in well due to instantaneous removal of water from well [L]

s_t = drawdown in well at time t [L]

L = length of well screen [L]

r_c = radius of well casing [L]

$\ln(r_e/r_w)$ = empirical “shape factor” determined from tables provided in Bouwer and Rice (19760

r_e = equivalent radius over which head loss occurs [L]

r_w = radius of well (including gravel pack) [L]

H = static height of water in well [L]

b = saturated thickness of aquifer

SOURCE: Geraghty & Miller’s AQTESOLV™; Version 1.00 Documentation; October 17, 1989; Geraghty and Miller, Inc.; Reston, Virginia.

SLUG TEST METHOD FOR CONFINED AQUIFERS

REFERENCE: H. H. Cooper, J. D. Bredehoeft, and S. S. Papadopulos. Response of a finite-diameter well to an instantaneous charge of water, Water Resource Research, Vol. 3, No. 1, pp. 263-269.

ASSUMPTIONS:

- Aquifer has infinite areal extent
- Aquifer is homogeneous, isotropic, and of uniform thickness
- Aquifer potentiometric surface is initially horizontal
- A volume of water, V, is injected into or discharged from the well instantaneously
- Pumping well is fully penetrating
- Flow to pumping well is horizontal
- Aquifer is confined
- Flow is unsteady
- Water is released instantaneously from storage with decline of hydraulic head
- Diameter of pumping well is very small so that storage in the well can be neglected

SOLUTION: *Integral solution for dimensionless drawdown in well:*

Laplace solution for response in well:

Where:

H = head in well at time t [L]

H_0 = initial head in well due to slug injection or extraction [L]

= r_w^2S/r_c^2 [dimensionless]

r_w = effective radius of well [L]

r_c = internal radius of well [L]

= Tt/r_c^2

J_0 = Bessel function of first kind, zero order

J_1 = Bessel function of first kind, first order

Y_0 = Bessel function of second kind, zero order

Y_1 = Bessel function of second kind, first order

K_0 = modified Bessel function of second kind, zero order

K_1 = modified Bessel function of second kind, first order

SOURCE: Geraghty & Miller's AQTESOLV™; Version 1.00 Documentation; October 17, 1989; Geraghty and Miller, Inc.; Reston, Virginia.

Standard Operating Procedure No. 415

LOW FLOW GROUNDWATER SAMPLING

Taken from U.S. Environmental Protection Agency – Region I, July 30, 1996, Revision 2.

Equipment: adjustable rate peristaltic pump;
1/4 to 3/8-inch PVC, polyethylene, or polypropylene tubing;
water level measuring device;
flow measurement supplies (e.g., graduated cylinder and stop watch);
power source;
indicator field parameter monitoring instruments - pH, Eh, dissolved oxygen (DO), turbidity, specific conductance, and temperature. If possible use a flow-through-cell to measure all listed parameters, except turbidity;
standards to perform field calibration of instruments;
decontamination supplies;
logbook;
sample bottles;
sample labels and chain-of-custody forms.

Note that use of a peristaltic pump limits the groundwater sampling depth to less than about 20 feet below ground surface.

1. Lower tubing into the well to the midpoint of the saturated screen length. If possible keep the tubing at least two feet above the bottom of the well. Ideally this should be done the day before.

2. Before starting pump, measure water level to nearest 0.01 foot.

3. Purge Well

Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize.

Monitor and record water level and pumping rate every 3 to 5 minutes during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should be reduced to the minimum capabilities of the pump (for example, 0.1 - 0.4 L/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first 15 minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then recover as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen). The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

If the recharge rate of the well is lower than extraction rate capabilities of the pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally the intake should not be moved during this recovery period). samples may then be collected even though the indicator field parameters have not stabilized.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (ideally; turbidity, temperature, specific conductance, pH, Eh, DO; at a minimum pH, specific conductance, turbidity or DO) every 3 to 5 minutes. Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at 3 to 5 minute intervals, are within the following limits:

turbidity (10%),
DO (10%),
specific conductance (3%),
temperature (3%),
pH (+ or - 0.1 unit),
ORP/Eh (+ or - 10 millivolts).

All measurements, except turbidity, ideally should be obtained using a flow-through-cell. Use the attached form for recording field measurements. Water samples for laboratory analyses must be collected before water has passed through the flow-through-cell (use a by-pass assembly or disconnect cell to obtain sample).

GROUNDWATER DATA FORM

GROUNDWATER DATA FORM

PROJECT INFORMATION

EVENT		Well Development		Groundwater Sampling		Low-Flow Groundwater Sampling
Project Name					Well ID	
Project No.					Start Date	
Field Personnel					End Date	

WELL AND DEVELOPMENT / PURGE INFORMATION

Casing ID	Stick Up	Purging Method	Tube/Pump Intake Depth
Screened Interval		Pump Make, Size, or Type	Pump Rate

DEPTH MEASUREMENTS

	INITIAL		FINAL	
	Depth	Time	Depth	Time
Product				
Groundwater from Top of Casing				
Casing Base from Top of Casing				

VOLUME PRODUCTION INFORMATION

Volume Type:		Borehole		Well Casing
Linear Feet of Water in Well				
Amount Equal to One Volume				
Total Volumes Produced				
Well Purged Dry?				

NOTES:

PHYSICOCHEMICAL PARAMETERS

Date	Time (24 hour)	Flow Rate (____)	No. of Vol Removed (#)	Volume Purged (gal)	Depth to Water (ft BTOC)	Drawdown (ft)	Temp (° C)	pH	Conduct. (mS/cm)	TDS (ppm)	Dissolv. Oxygen (ppm)	Eh (mV)	PID (ppm)	Turbid. (ntu)	Visual Clarity

GROUNDWATER DATA FORM

PROJECT INFORMATION					
EVENT		Well Development		Groundwater Sampling		Low-Flow Groundwater Sampling
Project Name				Well ID	
Project No.				Start Date	
Field Personnel				End Date	

PHYSICOCHEMICAL PARAMETERS

Date	Time (24 hour)	Flow Rate (____)	No. of Vol. Removed (#)	Volume Purged (gal)	Depth to Water (ft BTOC)	Drawdown (ft)	Temp (^{o}C)	pH	Conduct. (mS/cm)	TDS (ppm)	Dissolv. Oxygen (ppm)	Eh (mV)	PID (ppm)	Turbid. (ntu)	Visual Clarity

Standard Operating Procedure No. 500

EQUIPMENT DECONTAMINATION

1.0 PURPOSE OF PROCEDURE

Standard Operating Procedure (SOP) No. 500 describes the guidelines for decontamination of personnel and equipment during hazardous waste investigation field activities as specified in the Work Plan or as otherwise specified.

2.0 EXECUTION

2.1 GENERAL REQUIREMENTS

A. A decontamination plan should be developed and sufficiently scoped to address all the expected types and levels of contaminants at the site and the methods used to investigate them. Until proven otherwise, the decontamination plan should assume that all personnel and equipment exiting the area of potential contamination are contaminated and, therefore, comprehensive decontamination procedures must be implemented. Procedures for decontamination of equipment, as well as personal protective clothing and safety equipment, are included in the Site Health and Safety Plan (SHSP).

B. Personnel involved in decontamination efforts will be equipped with the same protective equipment as those conducting onsite investigations until a lower level of risk can be confirmed.

C. Procedures for decontamination of field personnel should be specifically addressed in the SHSP. These procedures should be followed and incorporated with the equipment decontamination procedures contained in the SAP to minimize exposure and cross-contamination potential.

D. Decontamination activities should be documented to verify that proper procedures are followed. Documentation shall be in accordance with the requirements specified in SOP No. 110, the Work Plan, and/or Quality Assurance Project Plan (QAPP).

E. The methods described in this SOP are considered sufficient for most hazardous waste investigations. However, more intensive site-specific procedures may be required under highly toxic or other "non-routine" conditions. In these cases, advice of in-house or consulting industrial hygienists and/or organic chemists may be of assistance in determining specific procedures necessary for decontamination.

F. Decontamination procedures may be subject to federal, state, local, and/or the client's regulations. All regulatory requirements must be satisfied, but the procedures adopted should be no less rigorous than those presented in this SOP.

G. Climatic conditions anticipated during the decontamination activities may play a significant factor in the procedures selected. Special facilities may be needed to compensate for weather conditions, such as temporary heated structures for winter work and windscreens for dust prevention. It may be necessary to establish special work conditions during periods of high heat stress.

2.2 SITE FACILITIES AND SUPPLIES

2.2.1 Site Selection

A. The equipment decontamination facility should be in an area where contaminants can be controlled and at the boundary of a "clean" zone. The location should also be selected to prevent equipment from being exposed to additional or other contamination. On large projects, a formal "Contamination Reduction Zone" should be established in which all decontamination efforts will be conducted. This area should be conspicuously marked as "off-limits" to all personnel not involved with the decontamination process.

B. Due to the volume of wastewater generated, if permitted, the equipment decontamination area should be located where decontamination fluids and oily wastes can be easily discarded or discharged into controlled areas of waste, such as existing pits or lagoons, if the potential mixing of contaminants is allowed. However, this should be prohibited until all investigation activity in those areas is complete.

C. The decontamination area should have adequate storage area for storing unused drums, used drums containing spent decontamination fluids and waste, and trash containers, until such time that they can be relocated or disposed offsite.

2.2.2 Decontamination Pad

A. Some sites under investigation may have an existing decontamination area. If an area has previously been constructed, it should be evaluated for logistics capabilities such as water supply, electrical power, by-product handling capabilities, and cleanliness. If the existing area can be used or modified for use, the savings in costs and level of effort may be significant.

B. On small projects where only hand sampling or other small equipment is being used, several small wash tubs (filled with detergent and potable water) may be sufficient for decontamination.

2.2.3 Water Supply

A. Large volumes of water, often exceeding 1,000 gallons per day, may be required for cleaning, especially for drill rigs and other large equipment. The water used for equipment decontamination must be clean, potable water; municipal water supplies are generally adequate.

B. Stainless steel tank trucks or aluminum (if stainless steel is not available) can be used for onsite storage of the water supply. These tankers can be transported easily and are not excessively expensive. Typically, a week's supply of water can be stored onsite.

C. Water may also be stored in open-top watertight tanks or roll-off boxes located in the clean zone on the site. However, open-top tanks or box containers should not be used if airborne contaminants are present, unless a liner is used to cover the container. Containers should be steam-cleaned and acid-washed before use. Only containers used to store fresh water or inert materials should be used. Never use containers previously used to store petroleum products or organic chemicals.

2.2.4 Cleaning Equipment and Supplies

A. A portable steam cleaner or high-pressure hot water washer is normally required to clean contaminated heavy machinery (e.g., drill rig, backhoe, etc.) as well as materials and associated tools. Most washers and steam cleaners are commercially available for both portable generators or supplied AC power. Site logistical considerations may control the type of equipment required.

B. Typical steam cleaners/washers operate on relatively low water consumption rates (2 to 6 gpm) and can be used in conjunction with other cleaning fluids mixed with the water. High-pressure steam is preferred to high-pressure water because of steam's greater ability to volatilize organics and to remove oil and grease from equipment.

C. Units tend to malfunction easily and are susceptible to frequent maintenance and repair (especially under frequent use or use below freezing conditions). If possible, a second or back-up unit should be available onsite or arranged for with a nearby vendor.

D. On some small projects, garden sprayers may be used for final rinsing or cleaning. Typically, these sprayers are limited to use with small hand tools or sampling equipment. They also tend to break down and malfunction quickly.

E. Miscellaneous items required for decontamination efforts include some of the following:

- Potable water supply
- Decontamination solution
    - Potable water
    - Distilled water
    - Mild detergent (such as Alconox)
    - Isopropanol
- Brushes to remove heavy mud, dust, etc.
- Buckets
- Steam cleaner or high-pressure, hot water washer
- Racks normally metal (not wood) to hold miscellaneous equipment such as drill rods, sampling tools, etc.
- Utility pump to collect spent fluids for containerizing
- Drums to store contaminated materials (personal protective equipment, etc.)
- Tables (not wood) to hold small items after/during cleaning

- Plastic sheeting to wrap decontaminated equipment, tools, etc., after cleaning

2.3 EQUIPMENT AND VEHICLE DECONTAMINATION PROCEDURES

A. The following procedures are presented as a function of the level of contaminant concentration and are intended as general guidelines. Appropriate site procedures should be established based on the individual site characteristics and type of investigation prescribed.

1. Low to Moderate Contaminant Concentration:

    a. Steam or water rinse with potable water to remove mud or dirt

    b. Steam or hot water wash with a mixture of detergent and potable water

    c. Steam or hot water rinse with clean, potable water

    d. Air dry

2. High Contaminant Concentration:

    a. Steam rinse with potable water to remove mud or dirt.

    b. Steam wash with a mixture of detergent and potable water or other type of decontamination solution.

    c. Rinse critical pieces of sampling equipment with isopropanol.

    d. Steam rinse with clean, potable water.

    e. Air dry.

B. During decontamination of drilling equipment and accessories, clean hollow-stem auger flights, drill rods, and drill bits (particularly roller bits), as well as all couplings and threads. Generally, decontamination can be limited to the back portion of the drill rig and those parts that come in direct contact with samples or casing, or drilling equipment placed into or over the borehole.

C. Some items of drilling equipment cannot typically be decontaminated; these include wood materials (planks, etc.), porous hoses, engine air filters, etc. These items should not be removed from the site until ready to dispose of in an appropriate manner.

Other drilling equipment (especially rotary drill rigs) that requires extensive decontamination are water or grout pumps. Flushing may be sufficient to clean them. However, if high concentration of constituents or visible product is known to exist, then disassembly and thorough cleaning of internal parts is required before removal of the equipment from the site.

D. The mud pumps, kelly, swivel, and suction hoses on rotary drill rigs should be cleaned by circulating a minimum of 1,000 gallons of clean water and cleaning solution through the system followed by a minimum of 200 gallons of clean water through the system, and finally rinsing with 50 gallons of clean water without recirculating the fluid.

2.4 SAMPLING EQUIPMENT DECONTAMINATION PROCEDURES

A. All sampling equipment that may contribute to the contamination of a sample must be thoroughly decontaminated before its initial use, unless specific documentation exists that the sampling equipment has been decontaminated.

B. Generally, sampling equipment can be cleaned by hand. The following procedure is given as a typical sequence that should be modified based on site conditions.

C. Split-spoon and Shelby-tube samplers, bailers, and other sampling equipment that can be cleaned by hand shall be decontaminated as follows:

1. Wash and scrub with detergent (non-ionic)
2. Tap water rinse
3. Isopropanol rinse
4. Distilled water rinse
5. Air dry
6. Wrap in aluminum foil, shiny side out, for transport

D. Steel tapes, water probes, transducers, thermometers, and water quality meters shall be rinsed in distilled water or cleaned in a detergent solution and rinsed in distilled water after each use.

E. All pumps will be cleaned in water/detergent solution and flushed with clean water after each use.

F. Use of high-pressure steam or hot water washing may be substituted for hand scrubbing if it effectively removes contaminants and soil and can be done safely without burning or contaminating the personnel. Special racks should be used to hold equipment while high-pressure washing.

G. More “complicated” samplers require more “complicated” decontamination procedures. Piston and other samplers with numerous internal parts should be avoided, if possible, on sites requiring extensive decontamination procedures.

2.5 WELL MATERIALS DECONTAMINATION PROCEDURES

Well-casing, whether constructed of PVC, stainless steel, or other materials will be cleaned with a steam cleaner or high-pressure hot-water washer before it is installed. All well construction materials will be handled while wearing latex gloves.

2.6 DISPOSAL PRACTICES

2.6.1 General Disposal Requirements

A. Proper disposal of decontamination, sampling, and drilling byproducts shall be conducted to prevent the spread of contaminants offsite and to protect individuals who may encounter the potentially hazardous materials.

B. Disposal practices shall be in accordance with the procedures specified in the Work Plan. In general, sampling, drilling, and decontamination byproducts should be collected and disposed in a manner consistent with the accepted disposal practices for the type and concentration of wastes that may be contained in the byproducts.

C. Contaminated equipment or solutions will not be discarded in any manner that may lead to contamination of the environment by the migration of hazardous constituents from the site by air, surface, or subsurface transport mechanisms.

2.6.2 Onsite Disposal

A. Certain materials that are not contaminated or contain very low levels of contamination may be disposed of onsite. Such materials may include drill cuttings, wash water, drilling fluids, and water removed in developing or flushing wells. The low level of contamination in these materials should be confirmed before onsite disposal.

B. On controlled, secured facilities, most contaminated materials may remain on the site, provided they do not pose a threat of contamination of personnel or areas to be sampled.

2.6.3 Offsite Disposal

A. Materials that cannot be disposed of onsite will require that specific procedures be developed to provide for offsite disposal. Storage areas and/or tanks will be provided to hold the material onsite before disposal. Offsite disposal may be appropriate at various locations depending upon the nature of the waste.

B. Consideration should be given to use of sanitary and storm sewer systems, sanitary landfills, and licensed hazardous waste disposal facilities. Offsite disposal of wastes must comply with local, state, and federal laws and regulations. The Work Plan should identify the waste disposal options appropriate for offsite disposal of various classes of waste materials.